URANIUM-MINING PRACTICES AND COSTS AT TEN SALT WASH LEASE OPERATIONS OF UNION CARBIDE NUCLEAR CO.

By W. L. Dare

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URANIUM-MINING PRACTICES AND COSTS AT TEN SALT WASH LEASE OPERATIONS OF UNION CARBIDE NUCLEAR CO.[1]

by

W. L. Dare[2]

INTRODUCTION AND SUMMARY

This information circular is one of a series, published by the Federal Bureau of Mines, on methods and costs of mining uranium ore on the Colorado Plateau. This report describes the relatively small-scale operations of the Salt Wash miner: The mining method followed, the equipment used, and the production costs. It describes 10 lease-operated mines of Union Carbide Nuclear Co. that are typical of Salt Wash operations on the plateau. These mines lie within the Uravan mineral belt[3] and are in the Gateway, Bull Canyon, and Uravan mining districts. (See fig. 1.)

Generally the ore bodies occur as irregular, discontinuous layers of ore minerals within sandstone beds in the Salt Wash member of the Jurassic Morrison formation. The ore bodies sometimes occur as rolls, pods associated with carbonaceous trash, or tabular masses. Their size and erratic distribution preclude the use of a prearranged and uniform stoping system. The mining method is simply to follow the ore and leave open stopes behind.

Every Salt Wash miner has his own ideas on the use of certain types of equipment; however, all agree that thin, discontinuous Salt Wash ore bodies cannot be mined efficiently with large, ponderous, trackless equipment.

United States Vanadium Co. was organized in 1924 after radium mining on the plateau ceased.[4] This company first mined vanadium ores on East Rifle Creek, 11 miles northeast of Rifle, Colo., and built a mill near the town. On December 1, 1926, Union Carbide & Carbon Corp. acquired all of the assets of United States Vanadium Co. and continued operations under the same name

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[1] Work on manuscript completed December 1958.

[2] Mining engineer, Bureau of Mines, Region III, Denver, Colo.

[3] Fischer, R. P., and Hilpert, L. S., Geology of the Uravan Mineral Belt: Geol. Survey Bull. 988-A, 1952, 13 pp.

[4] Remmers, W. E. (president, United States Vanadium Co.), Industries' Activity in Uranium Production on the Colorado Plateau: Paper presented before Colorado Mining Association, Denver, Colo., February 1952.

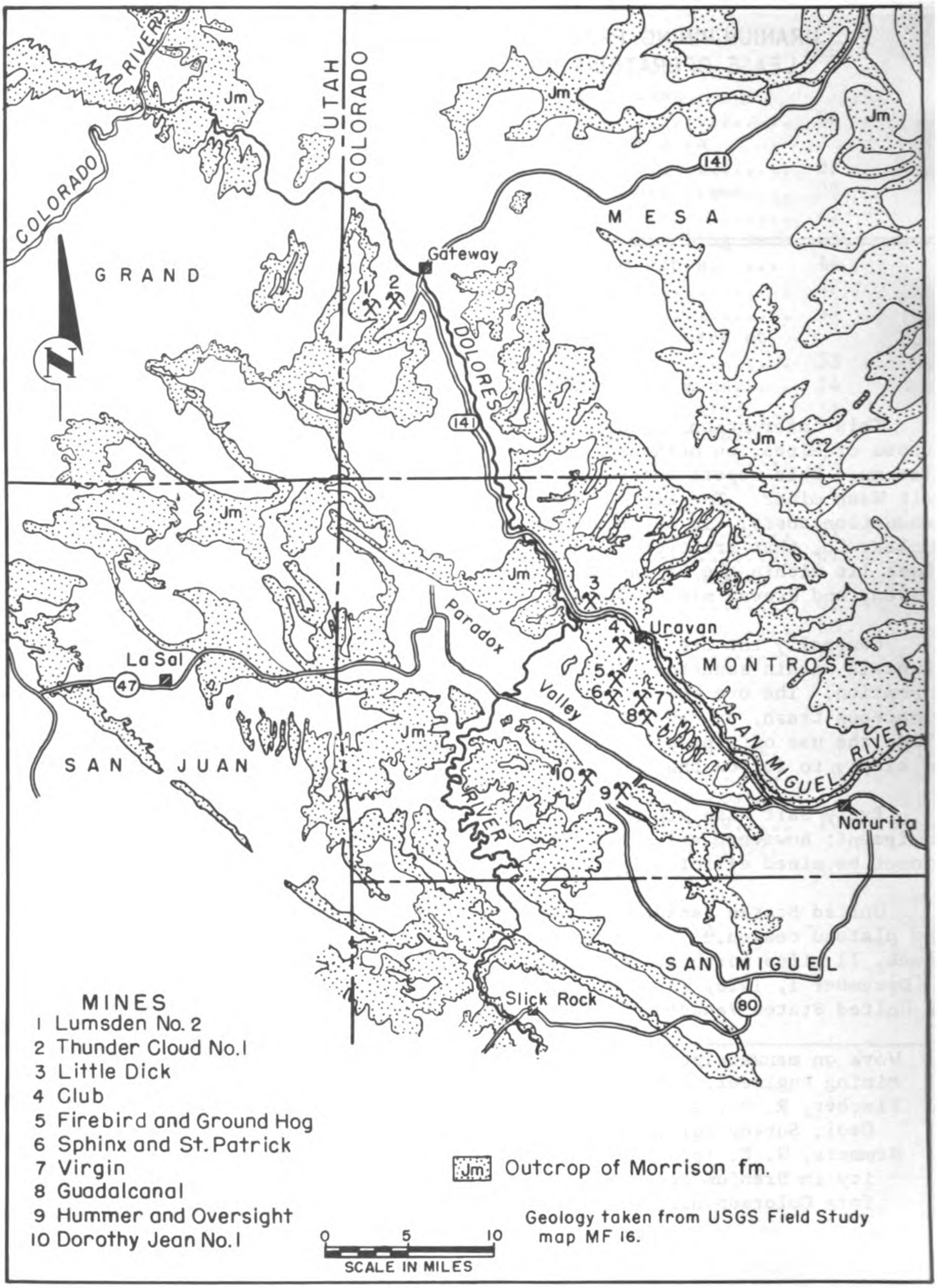

FIGURE 1. - Location of 10 Lease Operations of Union Carbide Nuclear Co.

except that the word "Company" was changed to "Corporation."[5] The name "United States Vanadium Co." was again used from 1951 to 1956, when the name "Union Carbide Nuclear Co." was adopted.

Activities on the Colorado Plateau have changed from the widespread promotional boom of the early 1950's to a quieter, more productive phase of mining. The efforts of small-scale Salt Wash miners have contributed much to the growth and stability of the uranium-producing industry.

ACKNOWLEDGMENTS

The assistance given by the officials, staffs, and lessees of Union Carbide Nuclear Co. is gratefully acknowledged. Special thanks are due J. F. Emerson, manager of mines; J. R. Borden, superintendent of mines, Uravan; and Bob Castor, chief surveyor, Uravan. Thanks also are due Dave Fulton and Ken Presley, engineers in the company's research and development department, for their review of this report.

GENERAL SALT WASH MINING METHODS AND COSTS

Mining Methods

As a whole, the Salt Wash ore deposits in the Uravan, Bull Canyon, and Gateway districts are irregular, roughly flat-lying zones containing nonuniformly distributed uranium-vanadium minerals. In these mineralized zones the ore bodies occur as lenses and pods of various shapes and sizes, lying in random arrangement and separated by irregular masses of waste or lean material. An ore deposit may comprise a small, closely grouped cluster of ore bodies that are extracted through one or more entries constituting the workings of one mine, or a deposit may be extensive and may be worked through several mines with connected workings. A deposit of the latter type trends southeasterly across Long Park; it is approximately 7,500 feet long and 2,000 feet wide and is worked in some 22 mines, many of which are interconnected. The maximum thickness of Salt Wash ore has been about 40 feet, but its average thickness has been only about 3 feet.

Open-stope mining is used to extract Salt Wash ore. Timber cribs and stulls are used occasionally to support the back. Much of the ore is mined by what might be termed "drift stoping," in which irregular drifts and rooms are driven along narrow, elongated ore pods following the ore in whatever direction or inclination it takes. Here, the ore is completely extracted on the advance, usually without the need of roof support. As new headings are turned off along ore splits or promising ore leads, the drifts and rooms become interconnected, and the pattern of the mine workings is that of a large stope or room whose back is supported by random pillars of waste. In a few mines, such as the Hummer, where the ore bodies are more tabular and continuous in certain areas, pillars of ore must be left, but in most Salt Wash deposits ore pillars are unnecessary as enough islands of noncommercial material can be left in place to provide adequate support. A systematic arrangement of rooms and pillars can seldom be planned, as the information gained by surface drilling does not reveal the exact pattern of the ore.

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[5] Hess, F. L., Rare Metals: Bureau of Mines Mineral Resources of the United States, Pt. 1, 1926, p. 270.

Sandstone backs not broken by fractures stand unsupported across spans approaching 40 feet. Such backs are seen in old stopes that have remained open for 30 or 40 years. The use of roof bolts has been limited in Salt Wash mines. Roof bolts cannot always be used to increase the roof span between ore pillars, because it is not always possible to tie a bolt to a competent rock at the point where it is needed owing to interlensing mudstone.

Jim Borden, superintendent of mines at Uravan for Union Carbide Nuclear Co., reported that, where ore reserves are small, his company insists on mine development being confined to the ore zone. To keep development costs as low as possible, it is important that every foot of drifting serve as exploration. The advantage of this outweighs the disadvantage of having an awkward haulage system, which often results when haulageways are driven within an undulating ore zone. Development of new but limited ore extensions, found by surface drilling ahead of the workings of an old mine, fall in this category. In mines having medium ore reserves the company tries to balance the value of keeping underground headings within the ore zone against the need for establishing a graded haulage level for efficient transportation. To stay close to an undulating ore zone yet advance a drift on grade, the miners drive the drift at an elevation that will enable them to intersect the bottom of the ore 1 to 10 feet above track level. They drive beneath the ore and mine through raises where the ore turns abruptly upward and occasionally must drive inclines where it plunges below track level. In newer mines with large ore reserves, development is planned basically around underground transportation. The haulage level is isolated from the undulating and dipping ore zone by driving most of it beneath the ore. Larger track equipment can then be used.

Finding ore-grade material in holes drilled from the surface is not always positive proof of the existence of an ore body. Frequently, drilling results are only indicative of what might be found underground. Time and again miners have driven to an ore hole and found that the drill bit had penetrated a small pod containing only a few tons of ore. The reverse also has been true, as many ore bodies have been found by miners who followed ore leads into ground that surface drilling indicated was unpromising.

Union Carbide Nuclear Co. relies on the judgment and experience of its lessees, many of whom have spent their working lives mining carnotite-type ores. Contrary to some information on mining methods published during the boom period on the plateau, the small-scale underground Salt Wash miner does not use large trackless equipment. He prefers small, standard equipment with which he can produce clean ore without costly overbreaking to provide operating space. Every lessee has his own opinion on mining techniques, but all agree that mechanization requiring large equipment is unfitted for mining thin, discontinuous Salt Wash ore bodies. Usually, the small-scale lessee does not have the ore reserves nor the cash reserves to warrant expenditures for large equipment and must make maximum use of his equipment, therefore little equipment is seen standing idle. To mine the changing ore faces selectively the Salt Wash miner breaks his rounds in a way to minimize sorting and uses the smallest possible amount of explosive to reduce losses in ore fines. Many lessees have found that a mortar hoe is a handy tool for cleaning out narrow ore benches.

The small-scale miner does more planning than is apparent at first. His plans must be flexible, as they have to be modified frequently to meet new conditions. Although it is sometimes difficult, the miner tries to keep enough headings in ore to assure a steady production and make maximum use of his equipment.

The 5- to 10-horsepower, compressed-air-operated, double-drum scraper hoist with a 24- to 30-inch semihoe bucket is the "workhouse" in the small Salt Wash mine. Small 40- to 50-pound drills mounted on pneumatic legs are used exclusively. Most Salt Wash miners prefer to use low, type-Z, C. S. Card Manufacturing Co. end-dump mine cars of 18.5-cubic-foot capacity, which were designed for Salt Wash mining.

Where the sandstone is sugary and poorly cemented, nearly all miners report that tungsten carbide insert chisel bits lose gage quickly with much less wear on the crown of the insert. In sandstone of this type they prefer one-use, four-wing bits, often hard-surfaced. In ground that is harder and better cemented, they generally favor the chisel bit; however, in fractured ground the chisel bit tends to bind,and in ground that contains much mudstone the water holes of the bit plug. Most miners use a four-hole burn cut to begin their break.

Union Carbide Nuclear Co. stresses "good housekeeping" in its leased mines. An experienced safety engineer makes routine visits to the mines to to make sure that the operators comply with all safety laws and practices. Federal Bureau of Mines first-aid courses are conducted for the lessees and their employees at the various mining communities by the safety engineer, who has been appointed a provisional instructor by the Bureau of Mines. The courses are examined by a State mine inspector, who has been appointed a certified examiner by the Bureau of Mines.

Mining Costs

Salt Wash mining is expensive, as the nature of the ore deposits limits the productivity per man-shift. Mining through crooked workings and hoisting and lowering mine cars through inclines are costly. The Salt Wash lessee cannot always keep a permanent mine crew, often because of the uncertainty of his ore reserves and the higher wages paid in other uranium-producing districts. Bad roads and scarce housing also hamper getting and keeping good miners.

The 10 lease operations described in this report are believed to be a representative cross section of the Salt Wash operations on the Colorado Plateau. These mines are entered through vertical shafts, slopes, or adits. When mining costs were computed the average output ranged from 70 to more than 1,000 tons of ore per month. The Hummer-Oversight operation was producing about 2,000 tons per month in the latter half of 1957.

Mining costs were obtained from the 10 operators for as near the same period of time as was practical and over a period long enough so that the costs would be representative. Most lessees do not have elaborate systems of cost accounting and keep books on a cash basis. Many buy their supplies in small quantities as needed and make their book entries at the time the bills are paid. Of the 10 cost breakdowns given in this circular, 8 are for concurrent periods of 12 to 15 consecutive months. Cost accountings for the other two operations cover shorter periods but are representative. The difference in the inventories of supplies at the beginning and end of each accounting period was too small to have real significance in the average unit costs. The small-mine operator is becoming more aware of the need for keeping good cost records, not only to compute taxes but also to have an accurate financial picture of his venture.

The direct development costs per ton as shown on the cost sheets given in this report are based on "dead work" payments made by the lessor to the lessees for development work completed. Development work for which the lessees are to be paid must be authorized in advance by company engineers and must be 6 by 7 feet in section unless the mine is in a cleanup stage. A heading driven along a seam of average-grade ore less than 18 inches thick is classed as development. The company furnishes all pipe, track, and timber. The following are development-work rates paid by Union Carbide Nuclear Co. in 1957.

Item and specifications		Rate
Raises:		
1-compartment, without timber	per foot	$8.00
1-compartment, timbered	do.	10.00
Drifts:		
7 by 7 feet, without pipe or track	do.	11.00
7 by 7 feet, with pipe and track	do.	15.00
6 by 7 feet, without pipe or track	do.	10.00
6 by 7 feet, with pipe and track	do.	14.00
Crosscuts:		
4 by 6 feet, without pipe or track	do.	8.00
4 by 6 feet, with pipe and track	do.	10.00
Inclines:		
Exceeding minus 12°, including pipe and track	do.	15.00
Test-hole drilling:		
Aimed as required	do.	.25
Timbering:		
3-piece, lagged and blocked	per set	6.50

The lessees did not make book entries for the value of their services; therefore, it was necessary to add an appropriate charge to the cost breakdowns to account for their labor and supervision. This charge was $500 per month for 8 of the 10 operations; $600 per month was charged for the largest of the 10 mines and $450 per month for the smallest. In the larger mines the principal job of the lessee was supervision, and the charge (less than 20 percent of the total labor cost) was entered against supervision. In the smaller mines, where the lessees had smaller crews and engaged more directly in ore

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production, the charge was spread between labor and supervision, so that 20 percent of the total (actual labor expense plus the charge allowed for lessee's service) was assigned to supervision.

There were many reasons why mining costs at the 10 lease operations differed. The most important were variations in the thickness and continuity of the ore. Other reasons were the way a mine was developed and its influence on the cost of bringing the ore to the surface; the difference in underground tramming conditions, particularly the number of inclines up which ore had to be hoisted; the type of ground, which determined bit, steel, and powder consumption; and the type of equipment used.

Although the other reasons undoubtedly affected the direct mining costs, it is surprising how closely the direct unit mining costs are related to ore thickness, despite the fact that each operator stressed some particular technique or had a different underground transportation problem. One curve on figure 2 shows this cost-thickness relation. The factor of ore continuity does not affect this curve, as development costs are separate from mining costs. The other curve on figure 2 shows the relation between the total direct costs per ton (which include both unit development and mining costs) and the tons produced per man-shift for all labor and supervision. The idealized curves are based on actual cost data compiled from records of each lessee. It is conceded that, if costs were obtained from more operations, the rate of change of the curves might be modified. It is also conceded that data points from a large number of Salt Wash mines will not fall directly on the curves but will lie on either side, depending on the peculiarities of each operation. It is believed, however, that these curves are generally representative of cost experience in mining Salt Wash deposits. Indirect costs, such as depreciation, payroll taxes, workmen's compensation insurance, and accounting, were not included in the data from which the curves were plotted.

Cost data are included in this report and follow the description of the operation to which they apply.

Tables 1 and 2 show the weighted and arithmetical averages of the direct and indirect unit costs of producing 1 ton of uranium ore from the 10 operations. In both tables an additional charge of $0.45 per ton was spread between mining and development supply costs to reflect the cost of pipe, rail, ties, and timber furnished by the lessor. Other costs that are borne by Union Carbide Nuclear Co. are not included in the cost breakdowns. These costs are for items such as exploratory drilling, engineering, administration, taxes and amortization of capital for certain initial development and construction of some small mine plants. Across the Salt Wash producing area these costs have been reported to average $2.00 to $3.00 per ton. In table 1 the mining costs of each lessee were weighted according to tonnage produced, then adjusted to a 15-month operating period. The resultant total is the average cost of producing 1 ton of Salt Wash ore from the 10 mines considered as a unit operation.

Table 2 shows the arithmetical averages of the unit costs; therefore, time and tonnage were not considered. This table is more representative of the cost of producing uranium ore from a typical Salt Wash mine. The costs

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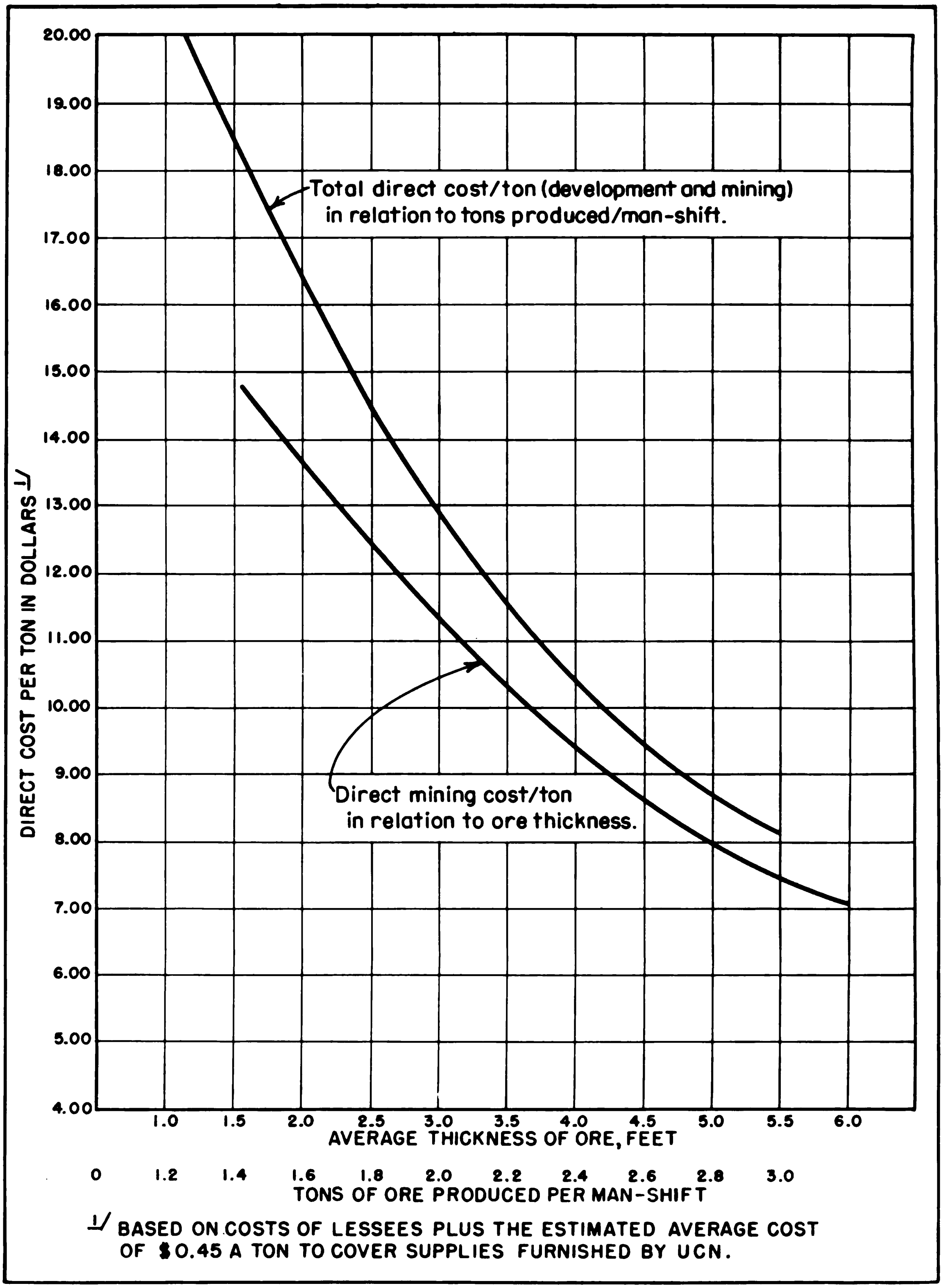

1/ BASED ON COSTS OF LESSEES PLUS THE ESTIMATED AVERAGE COST OF $0.45 A TON TO COVER SUPPLIES FURNISHED BY UCN.

FIGURE 2. - Curves Showing Relation of Production Costs to Ore Thickness and Productivity Per Man-Shift.

at the few operations that produced larger tonnages at lower costs were not as significant as when they were weighted; thus, these figures would seem to be of more interest to the average Salt Wash miner.

The Salt Wash miner also faces the problem of the rising cost of supplies. Table 3 lists a few common supplies and items of equipment, with their average prices in 1955, 1956, and 1957. The prices were obtained from supply houses in the area and are for small-quantity purchases.

TABLE 1. - Weighted averages of direct and indirect costs per ton of uranium ore from the 10 operations

1. Direct cost per ton of ore mined:

	Labor	Supervision	Explosives	Drill steel and bits	Fuel oil, gas, and electricity	Repairs and maintenance	Equipment rental	Other supplies[1]	Total
Development..	$1.25	$0.20	$0.17	$0.06	$0.13	$0.07	$0.07	$0.16	$2.11
Mining.......	5.40	.85	.69	.23	.53	.34	.37	.65	9.06
Total...	6.65	1.05	.86	.29	.66	.41	.44	.81	11.17

2. Indirect cost per ton of ore mined:[2]

Depreciation[3]...	$0.75
Transportation...	.15
Social security...	.13
Workmen's compensation...	.26
Unemployment compensation...	.14
Other insurance and taxes...	.07
Accounting and other...	.15
Total...	1.65

3. Costs in units of labor and explosives:

Ore produced per man-shift (labor and supervision).........tons	2.3
Explosives used per ton of ore......................... pounds	3.1

---

[1] Includes $0.45 per ton to cover the estimated cost of rail, pipe, timber, and other supplies furnished by Union Carbide Nuclear Co. (UCN).

[2] Does not include UCN costs for exploration, engineering, administration, taxes, and amortization of capital for certain initial development.

[3] Depreciation of lessees' equipment.

TABLE 2. - Arithmetical averages of direct and indirect costs per ton of uranium ore from the 10 operations

1. Direct cost per ton of ore mined:

	Labor	Supervision	Explosives	Drill steel and bits	Fuel oil, gas, and electricity	Repairs and maintenance	Equipment rental	Other supplies[1]	Total
Development..	$1.79	$0.34	$0.24	$0.09	$0.18	$0.06	$0.12	$0.21	$3.03
Mining.......	5.99	1.07	.75	.27	.59	.28	.44	.68	10.07
Total...	7.78	1.41	.99	.36	.77	.34	.56	.89	13.10

2. Indirect cost per ton of ore mined:[2]

Depreciation[3]..	$0.93
Transportation..	.23
Social security..	.13
Workmen's compensation..	.28
Unemployment compensation.....................................	.10
Other insurance and taxes.....................................	.11
Accounting and other..	.35
Total..	2.13

3. Costs in units of labor and explosives:

Ore produced per man-shift (labor and supervision).........	tons	2.1
Explosive used per ton of ore..........................	pounds	3.5

---

[1] Includes $0.45 per ton to cover the estimated cost of rail, pipe, timber, and other supplies furnished by UCN.

[2] Does not include UCN costs for exploration, engineering, administration, taxes, and amortization of capital for certain initial development.

[3] Depreciation of lessees' equipment.

TABLE 3. - Average prices for supplies and equipment, 1955-57, Uravan-Naturita area

Item	Average cost		
	1955	1956	1957
Scraper hoist, 2-drum, compressed-air 5-hp., 1,100-lb. pull at 80 p.s.i.............each	$1,160.00	$1,275.00	$1,400.00
Drill, 2-5/8-in. bore, integral with 4-ft., single-acting pneumatic leg..... do.	695.00	785.00	865.00

TABLE 3. - Average prices for supplies and equipment, 1955-57, Uravan-Naturita area (Con.)

Item	Average cost 1955	1956	1957
Drill steel, 7/8-in. hexagonal:			
Integral with tungsten carbide chisel bit:			
4-ft. length....each	16.10	17.75	19.50
5-ft. 3-in. length.... do.	16.45	18.10	19.90
6-ft. length.... do.	17.25	18.95	20.85
Carbon alloy, threaded or tapered bit end:			
4-ft. length.... do.	3.95	4.30	4.75
5-ft. length.... do.	6.55	7.20	7.90
6-ft. length.... do.	7.25	7.95	8.75
Drill bits, 1-use-types, 4-wing:			
Type A, 1-7/16- to 2-inch, tapered socket:			
Single bit.... do.	.20	.20	.245
Single bit in keg lot (300).... do.	.19	.19	.23
Type B, 1-7/16- to 2-inch, tapered socket:			
Single bit.... do.	.20	.20	.23
Single bit in keg lot (300).... do.	.19	.19	.22
Type C, 1-3/4-in., tapered socket:			
Single bit.... do.	.49	.49	.55
Single bit in keg lot (300).... do.	.49	.49	.54
Type D, 1-3/4-in., insert-type, threaded:			
Single bit.... do.	-	-	4.80
Wire rope, preferred-plow, hemp-center, 6 by 19:			
3/8-in.... per foot	.157	.166	.18
1/2-in.... do.	.187	.198	.21
Dynamite, 40- and 45-percent semigelatin:			
In 20-box lot (1/2 ton).... per 50-lb. box	9.75	10.50	11.25
Safety fuse, free-core: 3,000-ft. reel....each	35.00	35.00	36.00
Blasting caps, No. 6: 10-box lot (1,000).... do.	19.85	21.65	23.95

TEN LEASE OPERATIONS OF UNION CARBIDE NUCLEAR CO.

Club Mines

The Club mines are a group of old mines on the northeast end of Club Mesa, mainly in sec. 33, T. 48 N., R. 17 W., Uravan mining district, Montrose County, Colo. The town of Uravan is about 1 mile northeast of the mines. Ore bodies of the Club group comprise one of the largest uranium-vanadium deposits ever found in the Salt Wash member of the Morrison formation.

The Club mines consist of mine workings that underlie Yellow Jacket, Rambler, J. M., Beta, Beta Wonder, R. A. M., Joe Junior, Mill No. 1, Surprise,

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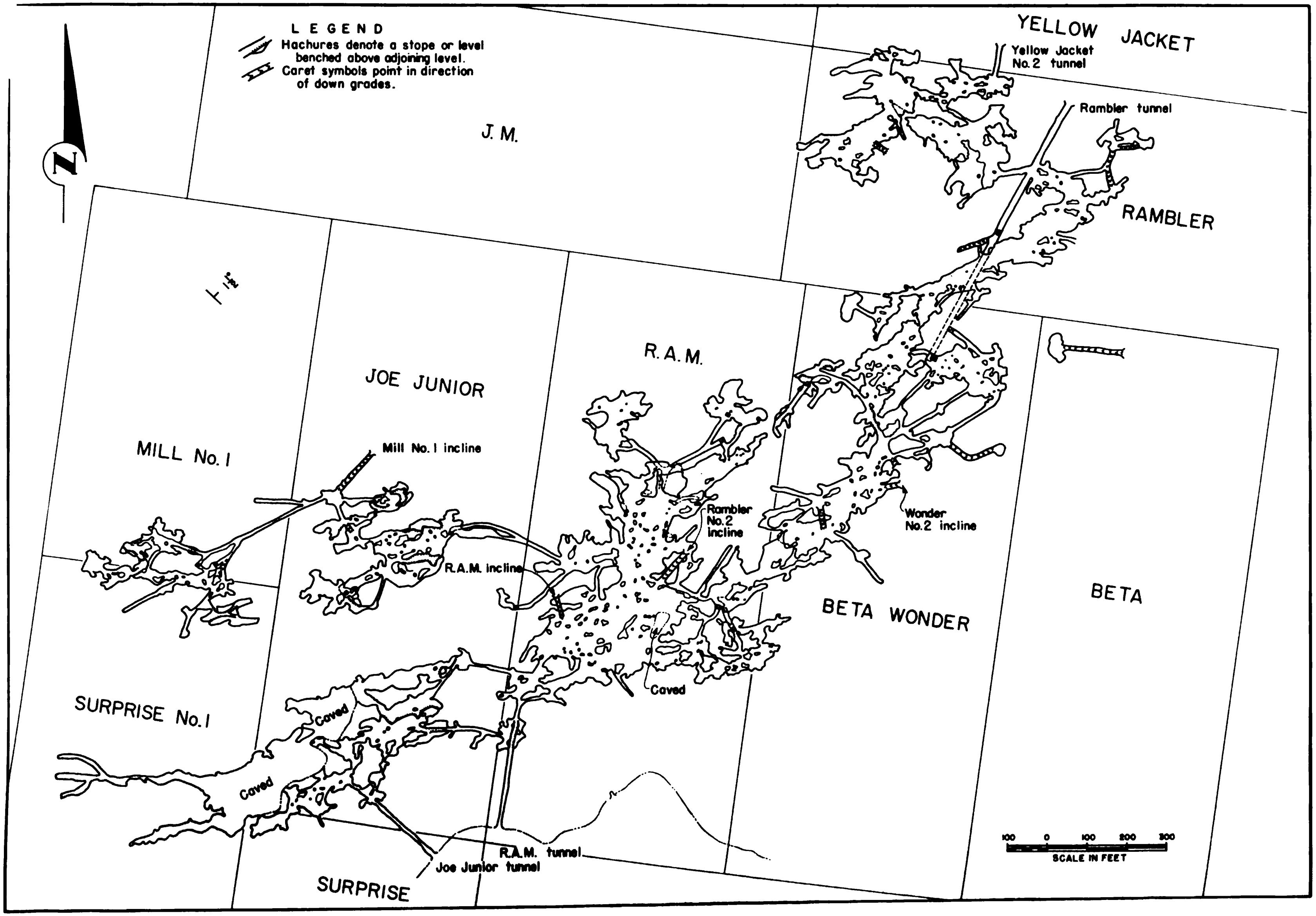

FIGURE 3.—Plan of Club Mines

and Surprise No. 1 claims. (See fig. 3.) The lessee whose operation is described here mined in ground bounded by the first seven claims. The area covered by the claims is relatively flat, ranging from 5,400 to 5,700 feet in altitude. Hieroglyphic Canyon, which bounds Club Mesa on the southeast, is immediately east of the mines, and the newly constructed Club Mesa-Long Park road ascends this canyon from Uravan.

The first claims on Club Mesa were located on the rim overlooking San Miguel River by Ike Hallet of Norwood, Colo., in 1899;[6] however, before 1910 only intermittent attempts were made to mine carnotite ores in the general area, which was formerly referred to as the Paradox district. This loosely defined district included mines on Club Mesa, Long Park, Saucer Basin, Dolores Bench, Atkinson Creek, Tabeguache Creek, and both rims of East Paradon Valley. General Vanadium Company of America, Baltimore, Md., a subsidiary of International Vanadium Co., Liverpool, England, was formed in 1909 and late in that year became the first organized company to acquire claims in the area. The second company to acquire ground was Standard Chemical Co., Pittsburgh, Pa., formed in 1910.[7] In November 1910 J. R. S. Smith located the Yellow Jacket claim and O. J. Adams the adjoining Beta claim. J. S. King located the Rambler claim in June 1911. Standard Chemical Co. located the Beta Wonder and R. A. M. claims and amended the location of the Yellow Jacket claim in the latter half of 1911, then located the Joe Junior and J. M. claims 2 years later. In 1912 Standard Chemical Co. owned 90 claims in the Paradox district, and in 1913 it owned 140. In April 1913 Standard Chemical Co. made its first shipment of high-grade ore, which is believed to have come from the Thunderbolt mine on the southwest wall of Paradox Valley. By the end of 1913 Standard Chemical was the largest producer of the radium ores in the United States. The first shipment of radium ore went to its allied company, Radium Chemical Co., in Pittsburgh.[8] It was reported that the company later sent ores and concentrates to its reduction mill at Canonsburg, Pa. The radium salts were then concentrated at the company radium research laboratory in Pittsburgh.[9]

Because there were no roads to Club Mesa in 1913, the ore that had been sorted and sacked at Standard's Club camp was packed on burros to the company orehouse in Long Park, Colo. The contract price to pack the ore was $8 to $10 per ton. In Long Park the ore was transferred to wagons for the 58-mile haul to the Denver and Rio Grande Southern Railroad (narrow-gage) station at Placerville, Colo. The six-horse teams, pulling two ore wagons in tandem, could haul 5 to 5-1/2 tons of ore and make the round trip in 1 week. This part of the trip to Pennsylvania cost $20 a ton.

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[6] Coffin, R. C., Radium, Uranium, and Vanadium Deposits of Southwestern Colorado: Colorado Geol. Survey Bull. 16, 1921, p. 152.

[7] Moore, R. B., and Kithil, K. L., A Preliminary Report on Uranium, Radium, and Vanadium: Bureau of Mines Bull. 70, 1916, pp. 19-25.

[8] Work cited in footnote 6, p. 110. Note. - P. 110 is the page in the Coffin bulletin cited.

[9] Flannery, J. M., Radium Plant of Standard Chemical Company: Colorado Bureau of Mines, 13th Biennial Rept., 1913-14, p. 114.

In 1914 Standard Chemical built a concentrator, called the Joe Junior mill, at its Ford camp on the San Miguel River, where the Union Carbide Nuclear Co. mill now stands. Ore from the Club mines (or Yellow Jacket group) was the major part of the mill feed. This ore was transported first on burros and later by wagons 1-1/2 miles and 600 feet lower in elevation down the mountainside. Standard Chemical Co. became the world's largest producer of radium and held that position until 1921. In 1915, when the world radium market was curtailed because of the war, the Club mines were thought to have been worked out.[10/] New reserves were soon found by diamond drilling. By 1920 these mines, developed by four inclines and four adits with approximately 10,000 feet of drifts and crosscuts, were reported to be the source of 45 percent of the uranium ore produced in Colorado.[11/]

Standard Chemical closed its mines in October 1921,[12/] owing to depressed business conditions in this country and Europe and did not reopen the mines later because American companies then were unable to compete with the government-controlled Belgian company that produced ores from the Belgian Congo. In 1928 United States Vanadium Corp., now Union Carbide Nuclear Co., bought the properties of Standard Chemical Co. and in 1935 began overhauling the mill to treat the ores for vanadium.[13 14/]

Lark Washburn, who lives on Club Mesa, has leased the Club group from Union Carbide Nuclear Co. since April 1956. The ore bodies are in the upper sandstone unit of the Salt Wash. Most of them have well-defined limits, but some low-grade ore is massive with poorly defined limits.[15/]

The rock formations near the Club mines strike about N. 45° W. and dip about 2° NE. The early-day prospectors located their first claims across outcrops of ore-bearing sandstone. Later, claims were located behind the outcrops and covered the overlying Brushy Basin member of the Morrison formation. Most of the ore in the Club group lies 20 to 70 feet below the surface. During the 12-month period for which mining costs are given, Washburn mined ore that averaged about 4-1/2 feet thick. The Club group of ore bodies, as a whole, is alined in a northeast direction. Some fossil logs and plant remains are replaced richly with carnotite, and in many places mudstone pebbles are rich in vanadium minerals.[16/]

[10/] Work cited in footnote 6, p. 199. Note. - P. 199 is the page in the Coffin bulletin cited.

[11/] Burwell, B., Carnotite Mining in Southwestern Colorado: Eng. Min. Jour., vol. 110, No. 16, pp. 755-758.

[12/] Hess, F. L., Mineral Resources of the United States, Pt. 1: Geol. Survey, 1921, p. 225.

[13/] Hess, F. L., Rare Metals: Bureau of Mines Mineral Resources of the United States, Pt. 1, 1928, p. 140.

[14/] Hess, F. L., Rare Metals: Bureau of Mines Minerals Yearbook, 1935, p. 557

[15/] Fischer, R. P., Vanadium Deposits of Colorado and Utah: Geol. Survey Bull. 936-P, 1942, p. 387.

[16/] Cater, F. W., Jr., Geology of the Davis Mesa Quadrangle, Colorado: Geol. Survey Quadrangle Map GQ 71, 1955.

The old development entries were adits or inclines. The old-time miners drove the Rambler adit beneath the ore and dropped the ore to the adit level through chutes. Wheelbarrows generally were used in the stopes.

Before May 1, 1957, Washburn operated the Club mines under a conventional lease contract, concentrating his efforts principally on developing and mining new ore bodies or extensions of previously mined ore bodies found by exploratory drilling. As the number of uninvestigated ore holes decreased, he devoted more time to cleaning up ore remaining in the old stopes and drifting on any promising ore leads. On May 15, 1957, his lease was modified to match the changing conditions at the mine, and he began operating under a "55-45-type" contract, whereby he received 55 percent of the gross value of the ore and all allowances except the initial production bonus.

Cleaning up an old mine presents a somewhat different problem in underground haulage, especially when the mine workings are as extensive and irregular as those of the Club mines. Mining is not confined to any one stope for long periods. The working crews move frequently from one place in the mine to another and need small haulage units capable of being operated on adverse grades and not restricted to rails. Washburn uses both diesel-powered Shuttle Buggies and horse-drawn, 16-cubic-foot-capacity, end-dump carts with rubber-tired wheels. (See figs. 4 and 5.) Therefore, the necessity of laying new track and relocating old track is eliminated, also of keeping bottoms on track grade. Instead of using the old development entries, Washburn has found it advantageous to sink short slope-type entries to intersect the old workings near promising stoping areas. These slopes were driven on grades (near 15 percent) that could be pulled by ore buggies and horses. The maximum grade up which Washburn will allow a horse to pull a load is 25 percent, then only for a distance of about 30 feet. Washburn estimated that his average haulage distance is about 600 feet.

The buggies and carts are loaded by hand shoveling from muck sheets. Washburn believes that this is the cheapest and most efficient method of loading where production comes from scattered headings. At the surface the ore is trammed to timber trestles and dumped directly into trucks; ore bins are not needed. Ore taken from slopes without dumping facilities is hauled on the surface to a slope that has them.

The Shuttle Buggies were built by Young's Machine Co., Monticello, Utah. They have a struck capacity of 32 cubic feet and hold approximately 2 tons when the ore is heaped. The buggies are powered by 10-horsepower, one-cylinder, four-cycle, Deutz FIL 612 diesel engines manufactured in Germany, which drive a single set of wheels that are mounted under the dump box and have 32- by 8.8-inch, 12-ply tires. The buggies are steered by a set of smaller dual wheels mounted centrally under the driver and are 10 feet 6 inches long, 4 feet 4 inches wide, and 4 feet 4 inches high. The loading height of the box is 3 feet 6 inches.

The ore sandstone at the Club mines appears more friable than that in many Salt Wash deposits, and 13 to 17 holes are needed to break 5-1/2 feet of ground in a 6- by 7-foot drift. The four-hole burn cut is spotted beneath

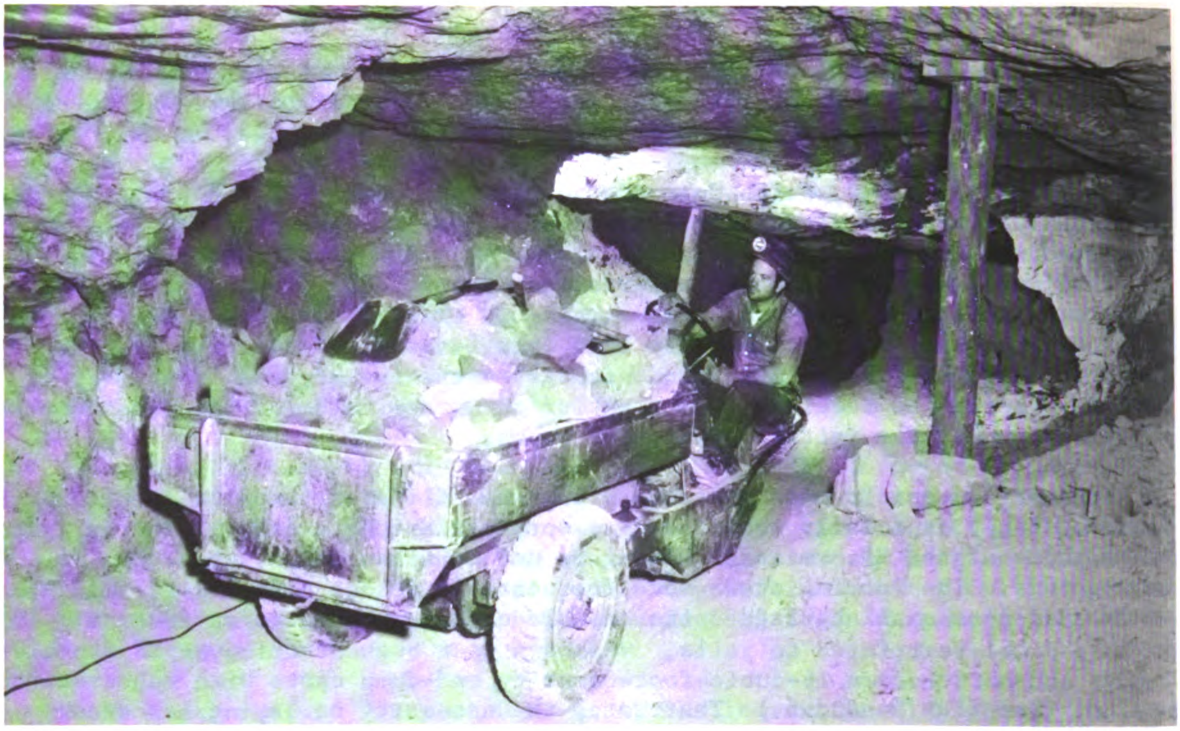

FIGURE 4. - Transporting Ore in Diesel-Powered Shuttle Buggie Through Club Workings.

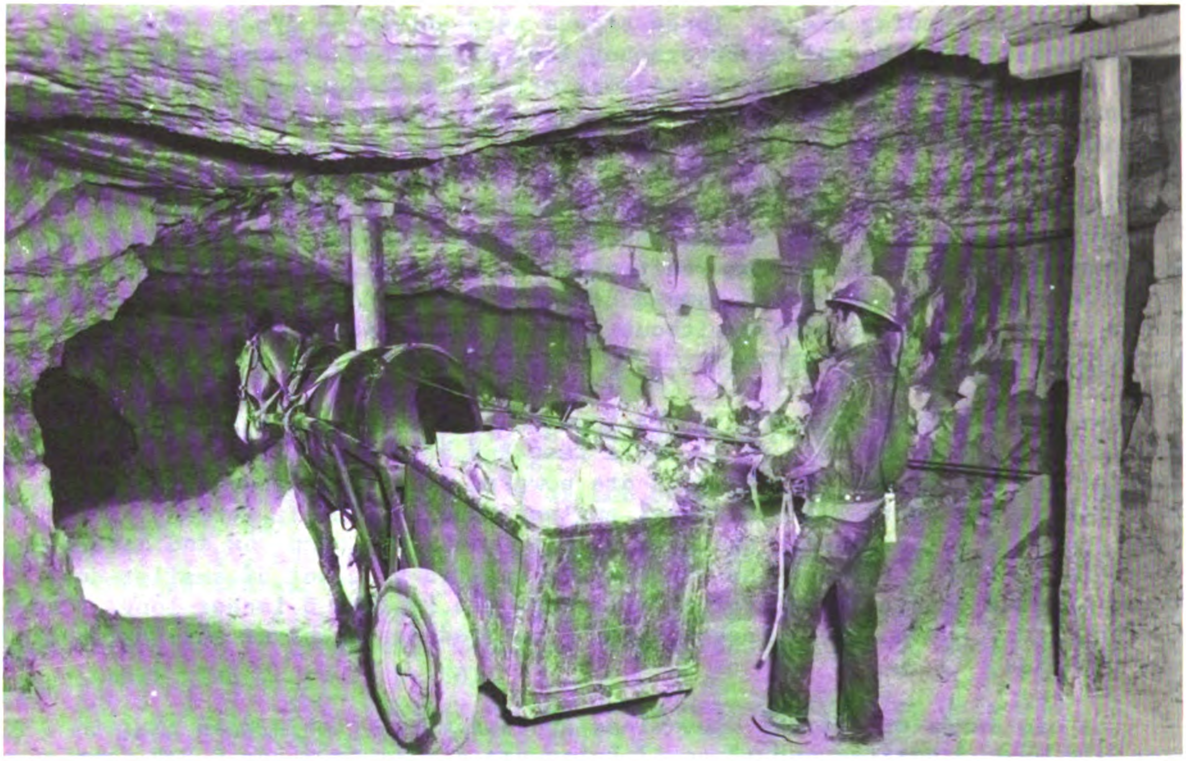

FIGURE 5. - Horse-Drawn Haulage, Club Workings.

the center of the face. Since Washburn began operating under the cleanup-type contract, he has not been required to maintain development headings 6 by 7 feet in section. When driving on an ore lead, he keeps the size of the drift to a minimum, thereby holding down explosive and rock-removal costs. Headings as narrow as 4-1/2 feet can accommodate the horse and cart, and if enough ore is found the small headings can be enlarged later.

Twenty-five-percent semigelatin dynamite breaks the soft sandstone easily. Four Cleveland H10AL drills mounted on 4-foot pneumatic legs, with 6-foot lengths of 7/8-inch hexagonal steel and one-use-type bits hard-faced with tube-borium welding rod, are used for rock drilling.

In addition to his contract on the Club mines, Washburn also has "75-25" cleanup-type contracts on the Tramp mine, which is on the Saucer Basin side of Club Mesa, and on a group of old mines comprising the Phonograph, Great Western, Elva S., and Honeymoon, all near the head of Hieroglyphic Canyon. The mining provlem at these two operations is about the same as that at the Club mines. Costs at the three operations were not kept separately, and the unit mining costs given in this report are averages for the three operations.

Washburn uses similar equipment at the three mines. He employs 12 men; 5 work at the Club mines, 3 at each of the other two mines, and 1 drives a truck. All work a 6-day week. Muckers and trammers are paid $2.00 per hour, drillers $2.25 per hour, and the Club mine leadman $2.50 per hour.

Production averaged 575 tons per month from the three operations in the 12 months for which costs were computed. Productivity of labor averaged 2.1 tons per man-shift for all labor and supervision. Washburn estimated that he has to produce 0.20 percent U_3O_8 ore to break even and above that percentage to make a profit. He does break lower grade material but must blend it with better ore to raise the grade of his shipments. Equipment used at the three mines operated by Washburn consists of the following items:

Number	Equipment item
1	Compressor, 315-c.f.m., Ingersoll-Rand, Gyroflo, propane-powered, at Club mines.
1	Compressor, 250-c.f.m., 2-stage Leroi, at Tramp mine.
1	Compressor, 125-c.f.m., 2-stage Leroi, at Phonograph mine.
4	Shuttle Buggy, 32-cu.-ft., 10-hp., diesel; 2 at Club mines, 1 at Tramp mine, and 1 at Phonograph mine.
4	Drill, 4-ft. airleg-mounted, Cleveland H10AL.
4	End-dump cart, 16-cu.-ft., rubber-tired wheels, horsedrawn.
4	Horses.

Name of mines: Club, Tramp and Phonograph.	Mining method: Open stoping with random pillar support.
Ore mined, tons: 6,920.	Period covered: April 1956 to April 1957.

1. Direct cost per ton of ore mined, development and mining:[1]

Labor	$7.43
Supervision[2]	.87
Explosives	.83
Drill steel and bits	.25
Fuel oil, gas, etc	.57
Repairs and maintenance	.69
Other supplies	.26
Total	10.90

2. Indirect cost per ton of ore mined:

Depreciation[3]	$0.84
Transportation	.05
Social security	.17
Workmen's compensation insurance	.37
Unemployment compensation	.22
Other insurance and taxes	.02
Other	.02
Total	1.69

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor	3.6
Total, including supervision	3.9
Tons per man-shift:	
Labor	2.2
Total, including supervision	2.1
Explosives, 25-percent semigelatin, pounds per ton	2.9

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[1] No breakdown between development and mining; costs do not include pipe, timber, etc., furnished by lessor.

[2] Supervisory cost is not a cash outlay by lessee but an allotted $500 per month ($0.87 per ton) for lessee's supervision.

[3] Depreciation of lessee's equipment.

Sphinx and St. Patrick Mines

The Sphinx, St. Patrick, and Florence Nellie claims are in sec. 20, T. 47 N., R. 17 W., Uravan mining district, on the Long Park side of Hieroglyphic Canyon. Long Park was one of the earliest known Colorado Plateau uranium-vanadium-bearing areas. The first mining claims were located a few years before 1905 along outcrops of ore in the Salt Wash sandstone that borders the edges of the park. Before 1950 the Long Park area was called the Vixen district and sometimes the Naturita district. It is bounded on the north by the irregular tributary canyons and washes of Hieroglyphic Canyon, on the east by the San Miguel River, and on the west by the northeast rim of East Paradox Valley. Altitudes in the vicinity of Long Park range from 5,100 feet at the San Miguel River to 6,800 feet near the northeast rim of East Paradox Valley; beyond the rimrocks the land drops sharply to an altitude of 5,200 feet in the center of the valley. Long Park itself is an elongated, relatively flat, natural, parklike area about 3 miles long and 1/4 to 3/4 mile wide. It parallels Paradox Valley, lying about 1 mile east of the rim rocks. Altitudes in Long Park range from 6,300 to 6,450 feet.

The Long Park area has been a principal source of uranium-vanadium ores. It was estimated that half the radium-vanadium ore mined in the Uravan district between 1911 and 1945 came from this small area.[17]

Formations exposed near Long Park are the Jurassic Morrison and the Cretaceous Burro Canyon. The beds strike about N. 50° W. and dip 5° to 15° NE. The Morrison formation near Long Park is about 700 feet thick, its Brushy Basin and Salt Wash members each comprising about half of this thickness. The Salt Wash member crops out extensively in the drainage basin of Hieroglyphic Canyon, in the higher area between Long Park and the rim of Paradox Valley, and along the washes that drain into the San miguel River. The Brushy Basin member, consisting predominantly of variegated shales, forms irregular slopes and badland-type topography east of the park. The massive sandstone of the Burro Canyon formation, which is 60 to 100 feet thick, caps many of the northeast-trending ridges east of Long Park. It forms the vertical cliffs seen at many places along the canyon walls.

The ore bodies in Long Park occur in sandstone lenses in the upper part of the Salt Wash. In some mines ore is found at several elevations, either in overlapping sandstone lenses or in the upper and lower parts of a single lense and separated by a seam of mudstone.[18 19] The ore-bearing sandstone ranges from 10 to 80 feet in thickness and is light brown to light gray.[20] The sandstone contains lenses of mudstone, mudstone-pebble conglomerate, and carbonized fossil-plant remains. The ore occurs as tabular masses, rolls, irregularly mineralized accumulations associated with fossil-plant remains and trash pockets, or combinations of these features.

The ore bodies in the Sphinx and St. Patrick have been mined occasionally since about 1911. Clarence Neilson has produced uranium ore from these two mines since July 1950, mining under a cleanup-type contract since July 1956. Under this contract Neilson and his partner, Phil Klingingsmith, receive 75 percent of the gross value of the ore, including the haulage and development allowances specified in AEC Circular 5. The two partners pay for their development work and all supplies, including pipe, track, and timber.

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[17] Stephens, H. G., Diamond Drill Exploration in Long Park and Vicinity, Montrose County, Colo.: AEC, TEM 110, 1950, p. 6.

[18] Cater, F. W., Jr., Geology of the Davis Mesa Quadrangle, Colorado: Geol. Survey Quadrangle Map GQ 71, 1955.

[19] Cater, F. W., Jr., Butler, A. P., Jr., and McKay, E. J., Geology of the Uravan Quadrangle, Colorado: Geol. Survey Quadrangle Map CQ 78, 1955.

[20] Work cited in footnote 17.

The beds near the Sphinx and St. Patrick mines strike about N. 50° W. and dip 6°-8° NE.; however, the Sphinx and St. Patrick ore bodies have a pronounced but irregular dip to the southeast, which is the general direction of the main ore trend. In many old stopes the ore dips gradually and evenly. In some stopes the position of the ore changes drastically, one ore shoot ending abruptly and another appearing at a different elevation. As many as three overlapping ore lenses have been penetrated in some exploratory drill holes. As much as 6 to 8 feet of barren rock has been found between the lower and middle ore layer and as much as 18 feet between the middle and upper layer. Many ore rolls turn abruptly upward and terminate within a short distance.

Neilson estimated that the ore mined in 1956 had an average thickness of about 3-1/2 feet and a maximum thickness of 7 feet. Old stopes on the east half of the Florence Nellie claim are as high as 11 feet. However, the 11 feet may not have been solid ore but several individual ore seams within a vertical height of 11 feet. Neilson and Klingingsmith mine ore as thin as 10 inches when cleaning up old stopes or following thin seams in the hope of finding thicker ore.

Mudstone is often mineralized with uranium when it occurs as a thin band within the ore sandstone. Sometimes the lower 6 to 8 inches of a mudstone overlying an ore sandstone will be shipping grade. Occasionally, as much as 12 inches of ore-grade mudstone overlies a barren sandstone. Usually this mudstone is a blue mudstone-pebble conglomerate containing 0.18 to 0.20 percent U_3O_8, but occasionally it is higher grade. Mudstone ore is difficult to recognize underground, as it lacks the characteristic color of the sandstone ore. Only in sunlight can the inexperienced viewer see the thin smear of yellow uranium oxides on the laminations.

The Sphinx mine is entered through a 6- by 7-foot incline 105 feet long, driven S. 14° W. at minus 28° into the hillside. (See fig. 6.) Stopes on an upper split of the ore zone intersect the incline 70 feet from its collar. The St. Patrick mine is entered through a short adit. The portal is in a small wash that drains northward on the Florence Nellie claim, 850 feet northwest of the Sphinx incline, and was started in an ore outcrop near other old workings that break through to the surface. The adit was driven generally S. 65° E., and most of the St. Patrick workings aline with those of the Sphinx. (See fig. 7.)

The haulageways in the old sections of both mines are often small and very irregular. They were driven along the direction of the ore, with inclines driven to follow its vertical deviations. The newer drifts are 5 by 7 feet in section and, where possible, are advanced on grades that permit hand tramming. When following a thin ore seam, the partners prefer to keep the seam high in the face so that they can see if it plunges downward or widens from the bottom. (See fig. 8.) Where waste has to be broken to maintain a mining height, Neilson believes that it is better to take up bottom than to break into the distinct parting which is often above the ore. In common with

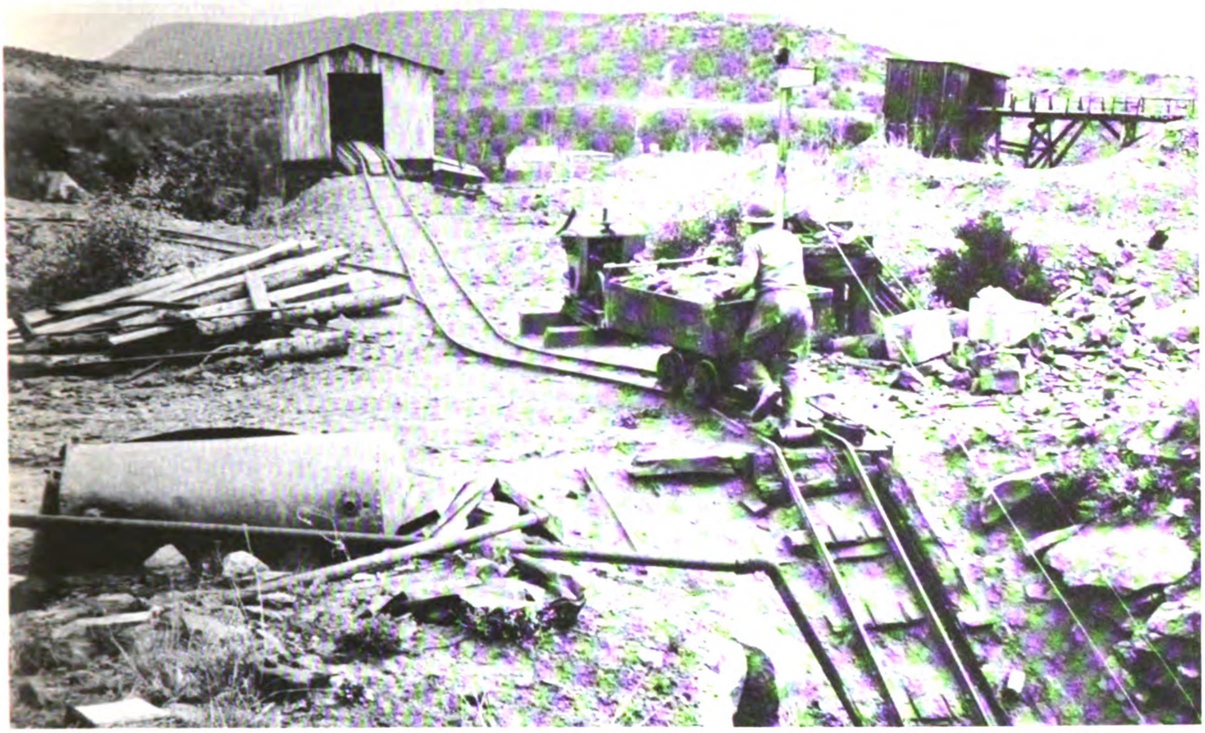

FIGURE 6. - Tramming Ore From Sphinx Incline to Ore Bin.

other miners on the plateau, Neilson and Klingingsmith use airleg-mounted drills and 7/8-inch hexagonal drill steel. They buy drill steel in 5-foot lengths and use a 1-5/8-inch, four-wing, one-use-type bit, which Klingingsmith hard-surfaces with oxyacetylene tube-borium welding rod.

Hard surfacing increases the drilling life of the one-use-type bit from about 15 to 120 feet in the ground at the Sphinx and St. Patrick mines. The tube-borium rod contains 30-down-mesh tungsten carbide particles. Using a No. 7 tip and a feathered flame, Klingingsmith first lays a bead across the crest of one of the wings (fig. 9). Fanning the wing with a minimum of heat causes the mass to flow down, plating and fusing it onto the wing and gage faces. Tube borium produces a serrated cutting edge on the wings, making them about 1/16 inch higher. No grinding is needed. A bit can be hard-surfaced in 3 to 5 minutes.

The ground is similar to that at the Club mines and is easy to drill and break. An average of 16 holes, loaded with 30-percent semigelatin dynamite breaks 5 feet of ground in a 5- by 7-foot heading. The drill round is patterned about a five-hole burn cut, the center hole of which is not loaded. Where the ground is fractured, the drillers can break to fractures with as few as 12 holes. When searching for new ore, Neilson uses sectional steel to drill 18-foot holes with the leg-mounted machines.

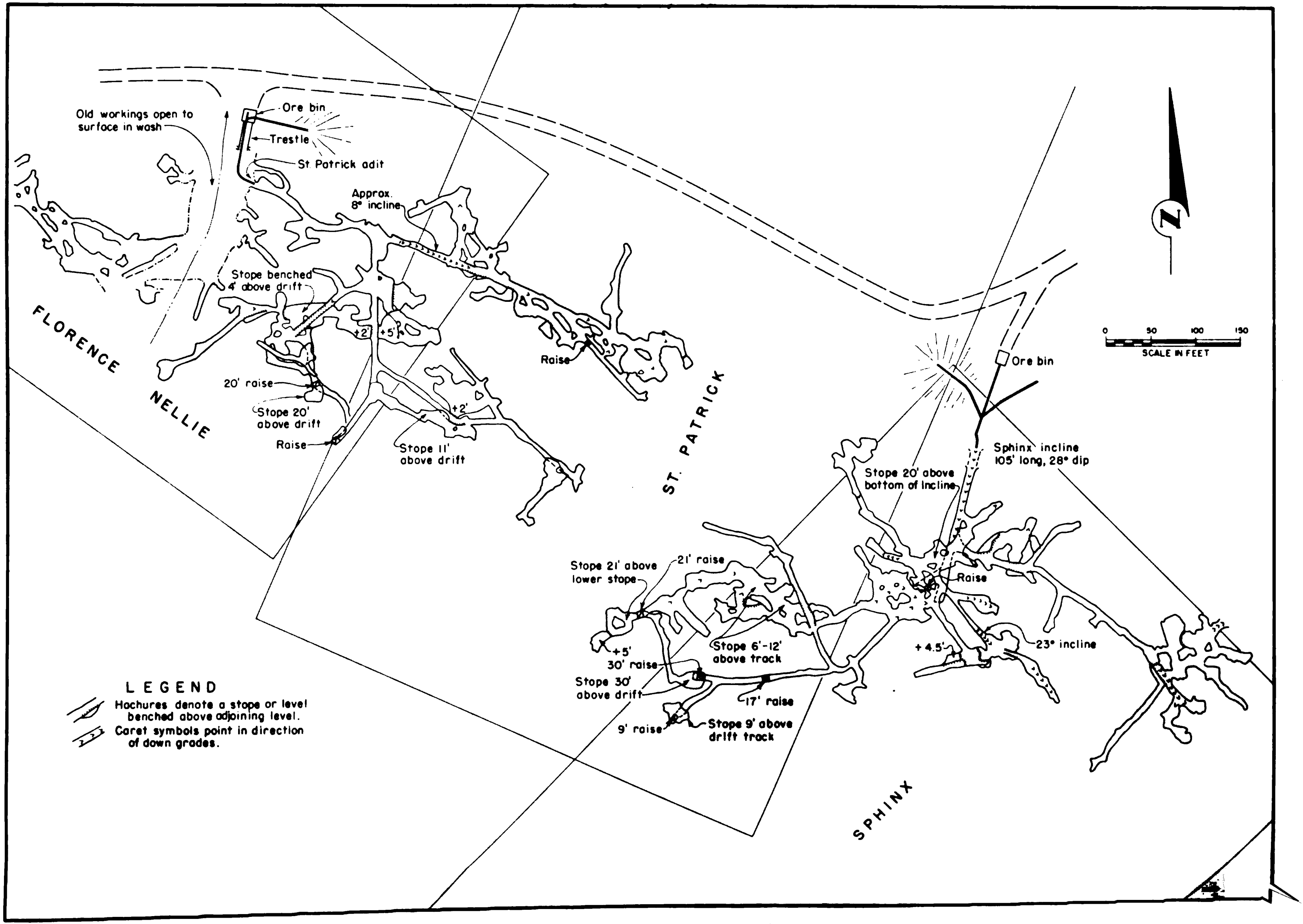
N
0 50 100 150
SCALE IN FEET
Old workings open to surface in wash
Ore bin
Trestle
St Patrick adit
Approx. 8° incline
Stope benched 4' above drift
+2'
+5'
20' raise
Stope 20' above drift
Raise
Stope 11' above drift
+2'
Raise
FLORENCE
NELLIE
ST. PATRICK
SPHINX
Ore bin
Sphinx incline 105' long, 28° dip
Stope 20' above bottom of Incline
Raise
+ 4.5'
23° incline
Stope 21' above lower stope
21' raise
+5'
30' raise
Stope 30' above drift
Stope 6'-12' above track
17' raise
9' raise
Stope 9' above drift track
LEGEND
Hachures denote a stope or level benched above adjoining level.
Caret symbols point in direction of down grades.

FIGURE 7. - Plan of St. Patrick and Sphinx Mines.

Original from THE OHIO STATE UNIVERSITY

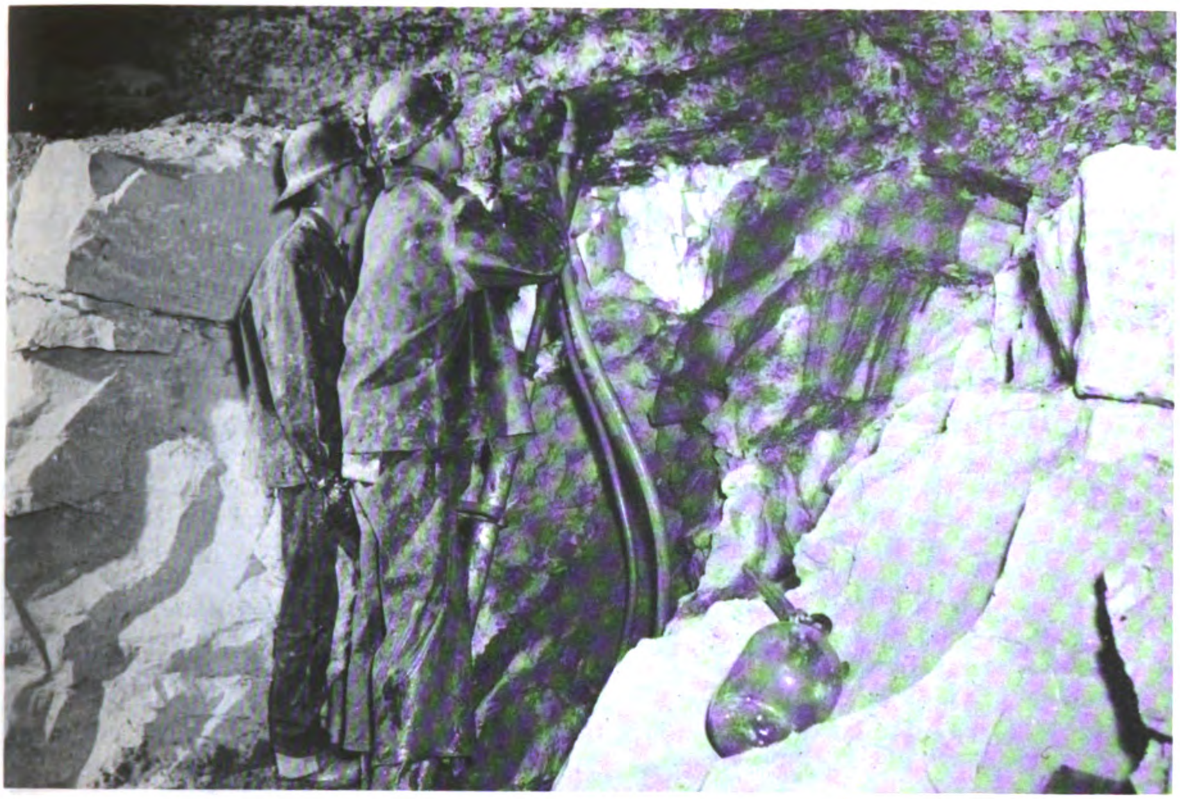

FIGURE 8. - Drilling Thin Ore Seam, Sphinx Mine.

Except for occasional stulls, little timber is needed underground. Most of the stopes are small and require no support. Stulls are needed in a few stopes where the backs are crossed by a system of large fractures that strike N. 30° to 40° W., roughly paralleling Paradox Valley. If all ore has been mined, Neilson and Klingingsmith are permitted to backfill the stopes.

The ore is transported underground in 20-cubic-foot mine cars which are hand-trammed over 16- and 20-pound rail laid to 18-inch gage. Single-drum, 5-horsepower air hoists are used to haul the cars on inclines. Wheelbarrows and timber slides are used to move the broken ore from stopes benched above the track level. The difficulty of maintaining a profitable grade of ore when mining thin and spotty deposits limits mine mechanization. Rough sorting when handloading mine cars helps maintain the grade of ore. (See fig. 10.) Heavy mortar hoes are used to clean up ore fines. As each car is brought to the surface, it is spot checked with a calibrated geiger counter to make sure that a shipping grade of 0.20- to 0.40-percent U_3O_8 is maintained.

When the mine was visited in 1957, the lessees were driving short inclines to reach old workings where the oldtime miners left what is now good ore. Ore production has averaged 125 tons per month from January 1956 to April 1957. During the last 3 months of this period, output was increased to an average of 280 tons per month.

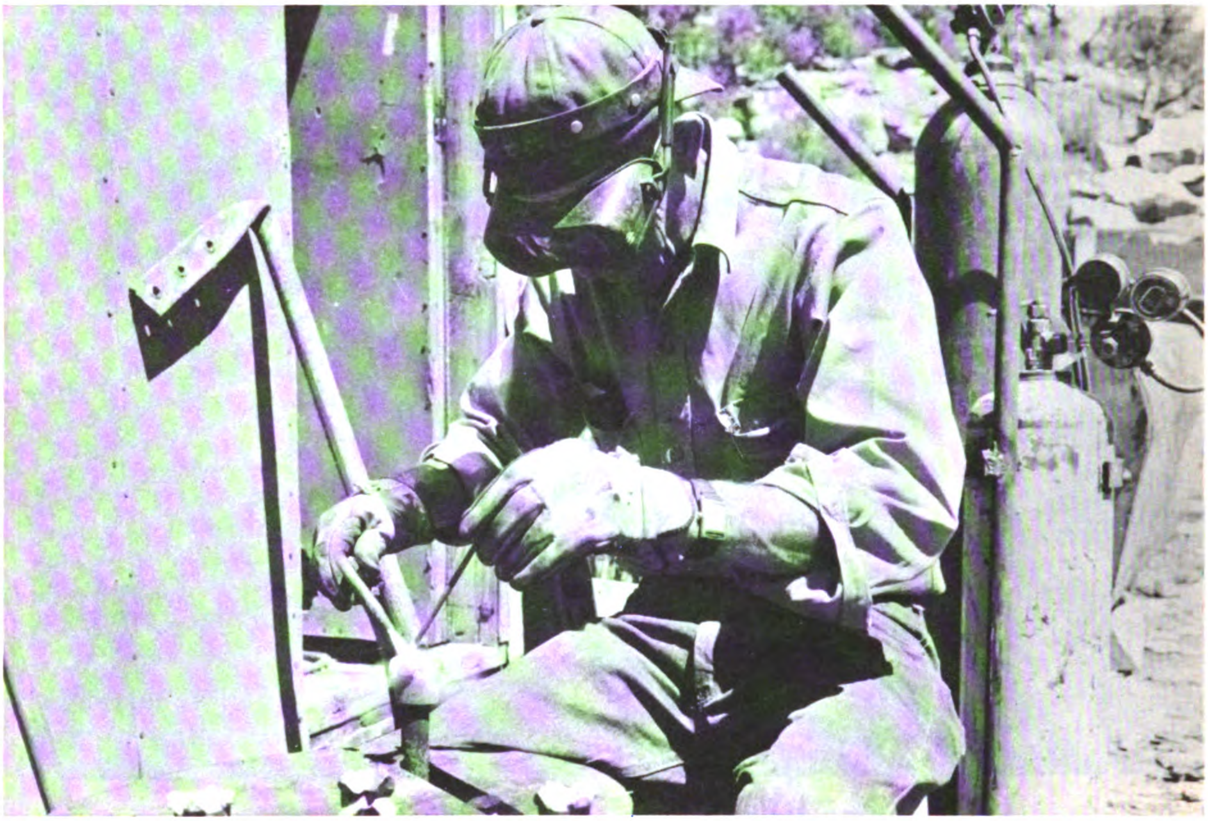

FIGURE 9. - Hard Surfacing One-Use-Type Bit, Sphinx Mine.

Development is particularly important where a limited number of ore holes remain to be investigated. The efforts of the small crew must be divided wisely between mining and development in order to maintain a steady production. Beside the two partners, three men are employed at the Sphinx and St. Patrick mines. This five-man crew consists of one hoistman, two muckers, and two drillers, but each man may be called upon to do any job. Drillers are paid $2.00 per hour and muckers $1.75 per hour. Neilson attempts to keep one driller in development headings at all times. Tons produced per man-shift for the whole crew averaged 1.8 during the 15-month cost period. The cost period is before Klingingsmith became Neilson's partner.

Equipment used at the Sphinx and St. Patrick mines comprises the following items:

Number	Equipment item
1	Compressor, 210-c.f.m., portable, 2-stage, Sullivan; diesel.
1	Compressor, 165-c.f.m., stationary, single-stage, Gardner-Denver XH; gas-engine and belt drive.
1	Hoist, 1-drum, utility surface, 1,500-lb. pull, 125 f.p.m., Sullivan PR-111; Wisconsin 4-cylinder, gasoline motor.

Number	Equipment item
9	Mine car, 20-cu.-ft., end-dump.
1	Scraper hoist, 2-drum, air, 5-hp., Joy S-211.
2	Tugger hoist, 1-drum, air, 5-hp., Joy E-112 and 7-1/2-hp. Ingersoll-Rand HU.
4	Drill, airleg-mounted, Ingersoll-Rand and Thor.
2	Stoper, Ingersoll-Rand R-38 and Thor.

Name of mines: Sphinx and St. Patrick. Mining method: Open stoping with random pillar support.

Ore mined, tons: 1,855. Period covered: January 1956 - April 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2]	$2.18	$0.44	$0.19	$0.07	$0.14	$0.08	$0.06	$0.07	$3.23
Mining	6.75	1.35	.57	.21	.45	.24	.18	.21	9.96
Total	8.93	1.79	.76	.28	.59	.32	.24	.28	13.19

2. Indirect cost per ton of ore mined:

Depreciation[3]	$1.01
Transportation, men and supplies	.64
Social security	.10
Workmen's compensation insurance	.23
Other insurance and taxes	.17
Accounting and other	.46
Ore haulage	.80
Total	3.41

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor	3.8
Total, including supervision	4.4
Tons per man-shift:	
Labor	2.1
Total, including supervision	1.8
Explosives, 30-percent semigelatin, pounds per ton	2.3

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[1] Supervision cost is not a cash outlay by lessee but is based partly on an allotted $500 per month ($4.04 per ton) for lessee's labor and supervision; $2.25 per ton is charged to labor.

[2] Development unit costs, including $0.99 for lessee's labor and supervision, are based both on "dead-work" payments of lessor and other development work.

[3] Depreciation of lessee's equipment.

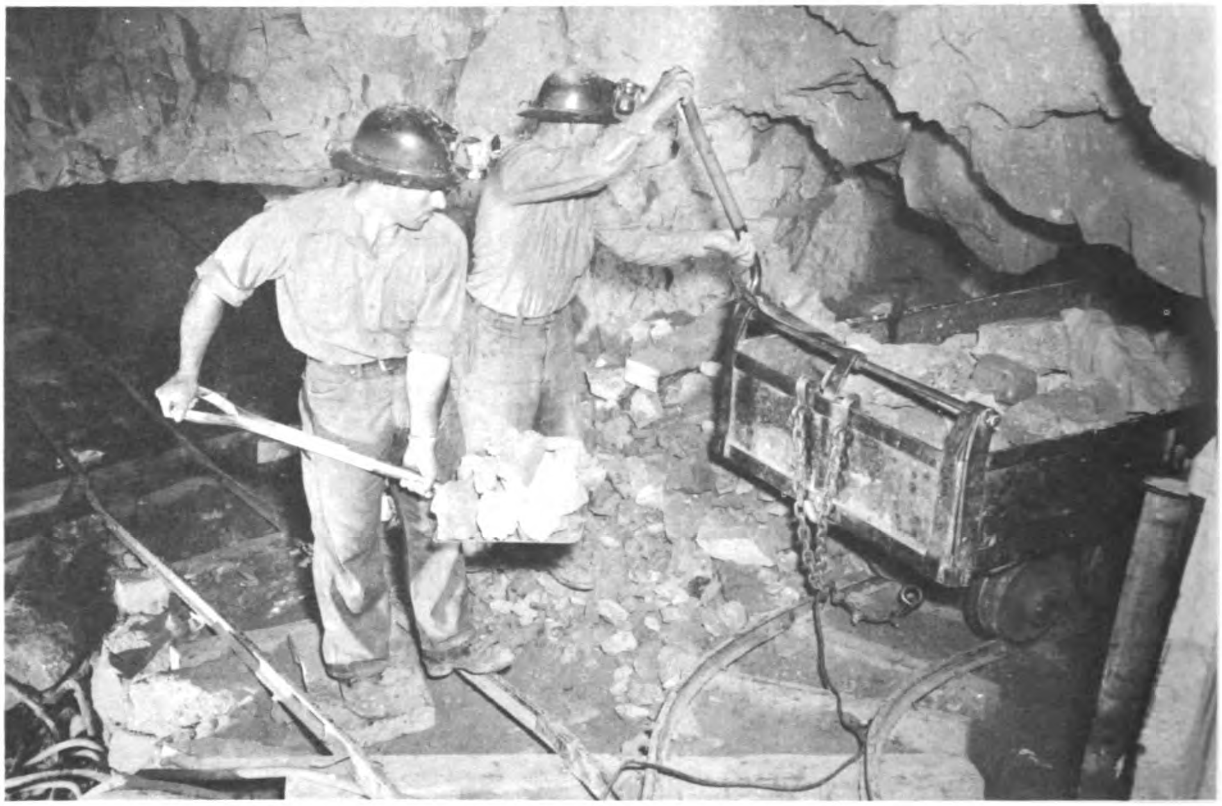


FIGURE 10. - Hand Loading, Sphinx Mine.

Firebird and Ground Hog Mines

The Firebird and Ground Hog mines are small, recently developed properties in secs. 17 and 20, T. 47 N., R. 17 W. They are in the Uravan mining district on the south rim of Hieroglyphic Canyon, about 1 mile northwest of Long Park proper. United States Vanadium Corp. located the Ground Hog claim in February 1940 and the Firebird claim in January 1942. Development of both properties was begun in June 1956 by the partners, Luther L. Brickey and Lloyd P. Alexander. Before that time the partners leased the nearby Bernard, C. F. C., and Moonbeem mines, which they continued to operate through December 1956. The C. F. C. and Moonbeem claims were located in 1915. Both partners began mining for United States Vanadium Corp. in the roscoelite-type ores at Rifle, Colo., in 1942.

Both the Firebird and the Ground Hog mines are entered through untimbered inclines 140 feet long, which were driven 7 by 7 feet in cross section at minus 20°. The inclines are about 800 feet apart (fig. 11), and a centrally located 315-c.f.m. compressor serves both mines. The ore is hoisted in 18.5-cubic-foot-capacity mine cars by small single-drum hoists mounted on 30-ton-capacity steel ore bins. Over each bin is a 10- by 10-foot hoisthouse built of wooden frames and corrugated sheet steel. Waste rock, excavated when sinking the

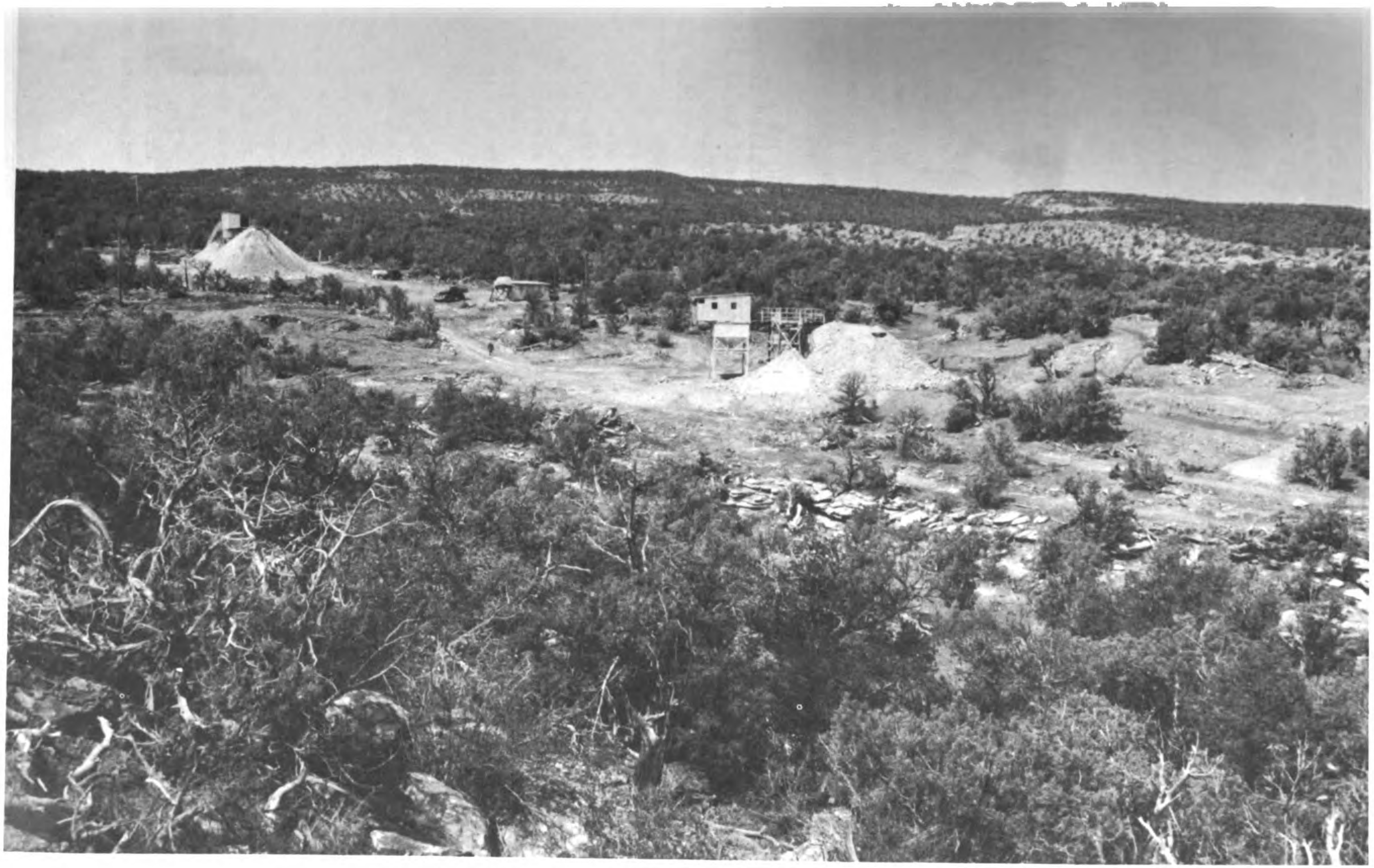


FIGURE 11. - Looking Southwest Toward Firebird (Right) and Ground Hog Mines.

inclines, was slushed between the collars of the inclines and the bins on approximately the same slope as the inclines. The inclines were sunk to the bottom of the ore, and the haulageways (6 by 7 feet in section) were driven in the ore zones.

Through 1957 the thickness of the ore at the Firebird and Ground Hog mines averaged about 3 feet. The ore layers are typical of the Salt Wash, rolling and undulating irregularly. The higher grade ore seams often are separated by barren or low-grade bands. The thinnest ore mined was 10 inches. The thickest ore occurred where the rolls turned abruptly upward to make ore bodies 6 to 7 feet high and 3 to 4 feet wide.

Drilling is done with airleg-mounted drills. When drifting in the massive and harder barren sandstone, the partners prefer 7/8-inch hexagonal steel with integral, 1-17/32-inch, tungsten carbide insert chisel bits. In the softer ore they use the same size steel but increase their drilling rate by employing one-use, 1-3/4-inch, four-wing Ingersoll-Rand Sandbits. They reported that chisel-type bits bind when drilling in fractured ground, and the waterhole tends to plug in the mudstone seams associated with the ore. The Sandbit has deep-slotted, tapered flutes between its wings; its wings protrude sharply above the body of the bit and the deep-set center waterhole. The deep-set waterhole reduces bit plugging, and the ample clearance between the wings permits easy passage of cuttings.

Fourteen holes, spaced about a four-hole burn cut, are drilled to break a 5-foot round in a 6- by 7-foot drift. The miners load seven sticks of 1-1/8- by 8-inch, 30-percent semigelatin dynamite into the four cut holes; they load six sticks into all reliever and trim holes and load the lifters full. The miners are not particularly concerned with fly ore in the stopes, as scrapers are used to slush the ore to the haulage drifts. Much of the ore has to be mined selectively. When either the upper or lower half of a face is ore, they normally break out the softer ore first. To recover a thin, high-grade seam of ore which they cannot afford to break separately, the miners drill all blastholes in waste so as to pull the ore to the cut in large slabs. These slabs then can be sorted from the waste. When there are waste seams in an ore face, the cut is placed in the ore with only enough holes in the waste to break it in large slabs. Generally, when thin ore is being followed it is kept high in the face if possible.

Every man in the mine is ore conscious. From the muck pile to the surface, the ore and waste are watched carefully to prevent ore from being thrown over the dump and waste getting into the bin. Often the low-grade ore is difficult to distinguish, and only in sunlight can the faint yellow ore streaks be seen.

The ore is moved underground from the stopes to the haulage drifts with scrapers. When the ore is at or below track level, it is scraped over timber ramps into the cars. From stopes above track level the ore is scraped directly onto the track (fig. 12) and picked up with an overhead loader (fig. 13). Where space is limited, hand mucking is often necessary. The ore is hand-trammed to the bottom of the inclines in low, 18.5-cubic-foot mine cars over 12-pound rail laid to 18-inch gage.

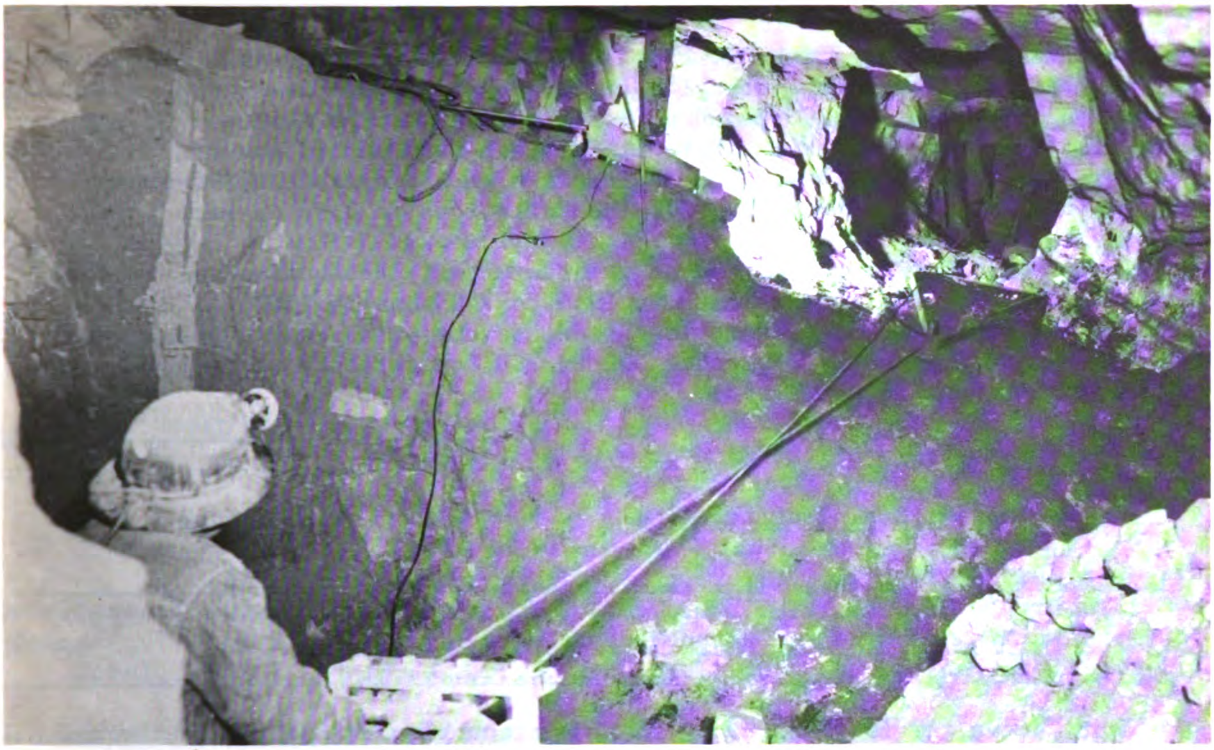


FIGURE 12. - Scraping Ore From Stope Into Drift, Ground Hog Mine.

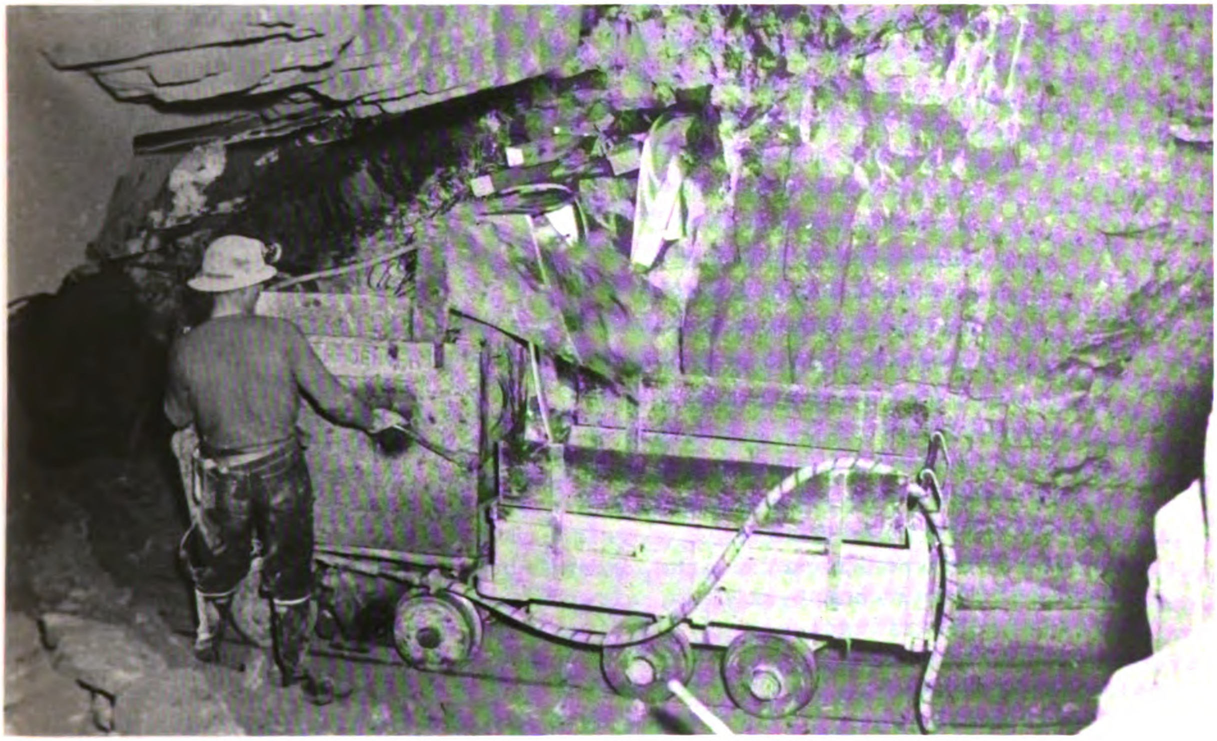


FIGURE 13. - Loading Ore, Ground Hog Mine.

The small Sasgen Derrick Co. hoist at the Firebird mine has a single 8-inch drum; is powered by a four-cylinder, Wisconsin, gasoline-driven engine; and has an approximate 2,600-pound pull at 150 f.p.m. The Sullivan PJ-112 hoist at the Ground Hog has a single 11-5/8-inch drum and is powered by a four-cylinder Buda gasoline-driven engine with an approximate 3,000-pound rope pull. About 250 feet of 6 by 19, 5/8-inch wire rope is used on each hoist.

In April 1957 five men worked at the two mines. Production was increased from an average of 188 tons a month in 1956 to 240 tons in 1957. The mine crew will be increased as new ore is opened, as the partners are obligated under the lease agreement to produce 500 to 700 tons a month when enough development headings are completed.

Hourly wage scale of the mine crew is as follows:

Job classification	Hourly rate
Lead driller	$2.15
Driller	2.00
Mucking machine and scraper operator	1.90
Hoistman	1.75

Ventilating air is supplied by small surface blowers mounted at the collars of 12-inch churn-drill holes and driven by small gasoline-powered engines. Before the mine was developed, Union Carbide Nuclear Co. churn-drilled a number of these holes to cut the ore zone where the best ore was found by exploratory drilling. As the workings are advanced and new ventilation holes intersected, the fans are moved to supply fresh air at the advanced working faces.

Equipment used at the Firebird and Ground Hog mines consists of the following items:

Number	Equipment item
1	Compressor, 315-c.f.m., 2-stage, Ingersoll-Rand; Caterpillar D8800 diesel.
1	Hoist, single 11-5/8-in. drum, 3,000-lb. pull, Sullivan, PJ-112; Buda 4-cylinder gasoline motor.
1	Hoist, single 8-in. drum, 2,600-lb. pull, 150-f.p.m., Sasgen Derrick Co.; Wisconsin 4-cylinder gasoline motor.
2	Loader, overhead, Eimco 12B and Gardner-Denver GD-10.
4	Mine car, 18.5-cu.-ft., end-dump, C. S. Card, low, type Z.
3	Drill, airleg-mounted, Ingersoll-Rand JR-38 and Gardner-Denver FL48.
2	Scraper hoist, 2-drum, air, 5-hp., Ingersoll-Rand A5NN-OH.
1	Tugger hoist, 1-drum, air, 7-1/2-hp., Ingersoll-Rand HU.
2	Centrifugal blower, American and 36-inch Buffalo; gasoline motors.

The unit costs given in the following table are combined averages for 9 months (July 1956 to April 1957) at the Firebird and Ground Hog mines and for

12 months (January 1956 to January 1957) at the Bernard, C. F. C., and Moonbeem mines. The total direct unit costs ($15.77) for the period are higher than average; however, the unit mining costs ($9.93) are about average. The higher than average unit development costs reflect the large amount of development work completed during the period.

Name of mines:	Firebird, Ground Hog, C. F. C., Moonbeem, and Bernard.	Mining method:	Open stoping with random pillar support.
Ore mined, tons:	2,971.	Period covered:	January 1956 to April 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2]......	$3.29	$0.93	$0.50	$0.12	$0.34	$0.04	$0.34	$0.28	$5.84
Mining[3]...........	5.58	1.59	.86	.18	.58	.08	.58	.48	9.93
Total.........	8.87	2.52	1.36	.30	.92	.12	.92	.76	15.77

2. Indirect cost per ton of ore mined:

Depreciation[4]..	$0.86
Transportation, men and supplies........................	.28
Social security..	.14
Workmen's compensation insurance........................	.28
Other insurance and taxes................................	.07
Accounting and other.....................................	.20
Camp expense..	.15
Total..	1.98

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor..	3.9
Total, including supervision.......................	4.8
Tons per man-shift:	
Labor..	2.5
Total, including supervision.......................	1.7
Explosives, 30-percent semigelatin dynamite, pounds per ton..	4.7

---

[1] Supervisory cost is not a cash outlay by lessees but an allotted $500 per month ($2.52 a ton) for the services of 1 of the partners. Other partner's time charged at driller's rate of $2.00 per hour and included in labor.

[2] Development unit costs, including the supervisory cost of $0.93 per ton, based on "dead-work" payments by lessor. High development unit costs reflect sinking the 2 inclines.

[3] Mining costs do not include timber, rail, pipe, etc., furnished by lessor.

[4] Depreciation of lessees' equipment.

Virgin Mine

The shaft-developed Virgin mine is in sec. 22, T. 47 N., R. 17 W., in the Uravan mining district, near the northeast border of Long Park. Shaft sinking was begun late in 1951, and the first ore was shipped in September 1952. D. C. Bunker, formerly of Cripple Creek, Colo., and operating as D. C. Bunker Mines, acquired a lease on the Virgin mine in September 1956. Previously, in partnership with R. D. Johnson, Bunker leased the Long Park No. 1, Triangulation, and Black Dinah mines in Long Park. The Virgin No. 3 claim was located by United States Vanadium Corp. in May 1950, and the adjoining Wednesday claim was located by H. D. Clark in August 1950.

Access to the Virgin workings is through a 367-foot, vertical, two-compartment cribbed shaft. Its single level is at 355 feet. The shaft compartments are 4 by 4 feet in the clear and are open-cribbed with 3- by 8-inch timber set on 8- by 8-inch bearers installed approximately every 20 feet. A small station, about 14 by 20 feet in plan, was cut in the upper sandstone unit of the Salt Wash. Except for one set of 8- by 8-inch timbers, the station requires no support. Occasional stulls are the only other timber used for back support in the Virgin mine. A 4-inch aluminum air line, 1-inch water line, and a 2-inch pump column are hung in the manway compartment of the shaft. The Virgin headframe is shown in figure 14.

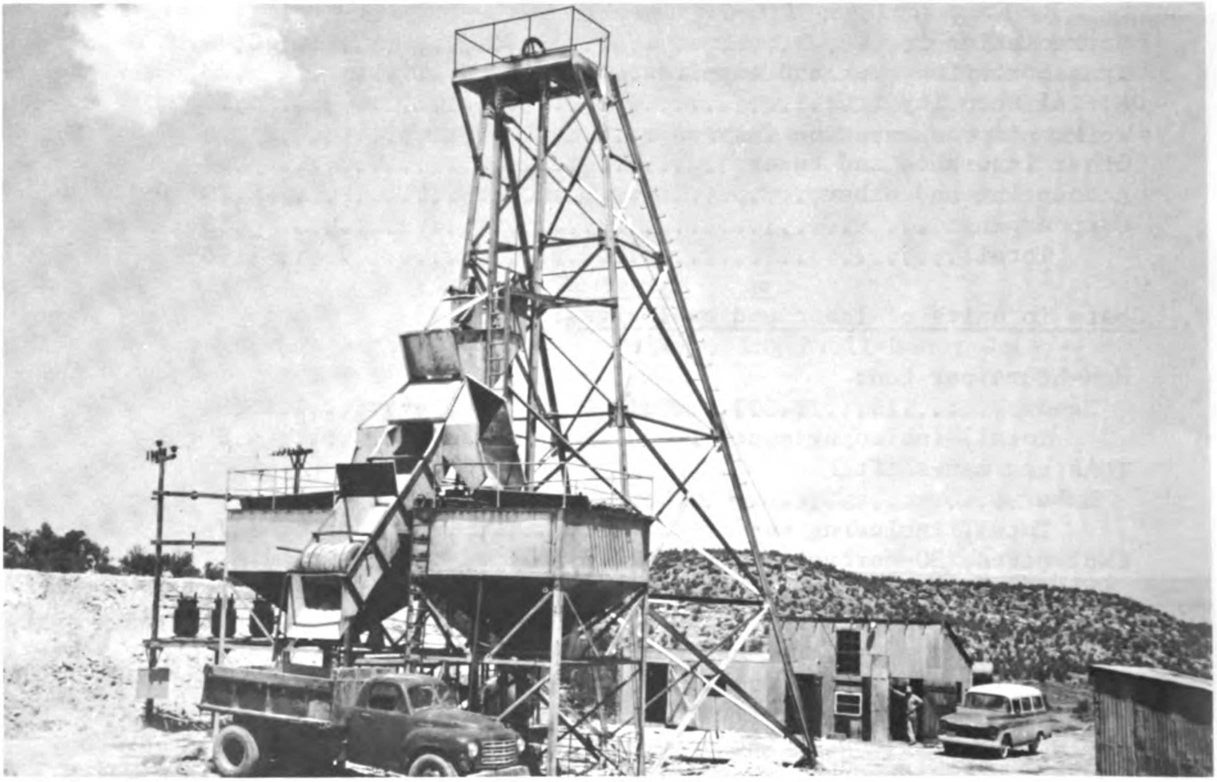


FIGURE 14. - Headframe at Virgin Shaft.

An unusual feature is the position of the station relative to the shaft. Instead of both shaft compartments opening onto the station from their wall-plate side, the station is driven from the end-plate side of the hoisting compartment. The skip is hung in the hoistway at right angles to the conventional position, and the skip guides are fastened to the wall plates. The dumping side of the skip faces the end of the single track that enters the station. The headframe was erected so that the bent of the front posts is perpendicular to the long axis of the compartments.

The shaft was sunk on the Virgin No. 3 claim near the northeast end of a cluster of small ore bodies 340 to 400 feet deep. Exploratory drilling indicated that these ore bodies underlie part of the Virgin No. 3 claim and extend south into ground that had been withdrawn from public entry under Public Land Order 459, effective March 30, 1948, and later amended by Public Land Order 698, effective February 15, 1951. (See fig. 15.) This ground is designated as Government Block B. Under terms of a mineral lease (ML-14) negotiated with the Atomic Energy Commission on October 19, 1951, Union Carbide Nuclear Co. has the right to mine the ore lying within the withdrawn ground.

The general dip of the beds is about 6° NE., the dip of the ore ranging from nearly horizontal to about 9° NE. The shaft was sunk on the downdip side of the ore, and the development drifts were driven updip in the ore zone, intersecting the ore bodies above the level of the track. Other drilling disclosed another group of ore bodies about 1,400 feet northeast on the adjoining Wednesday claim and downdip from the Virgin shaft. Owing to the dip of the beds and surface topography, these ore bodies are 550 to 600 feet deep and 65 to 105 feet lower than the shaft station. The ore is mined through a 940-foot incline driven from the older workings. Bunker's principal production thus far has come from the Wednesday ore bodies.

Most of the ore stoped to date on the Wednesday claim has been 4 to 6 feet thick and has had a maximum thickness of approximately 15 feet. The ore mined from the Virgin No. 3 claim and Government Block B has been thinner; the average thickness has been about 3-1/2 feet and the maximum thickness about 10 feet. The back is sandstone and has stood well for the most part. Roof bolting has not proved effective in increasing the widths of the stopes, as it is not always possible to anchor the bolts to competent rock at the places where they are most needed.

Blast holes are drilled with airleg-mounted drills and 7/8-inch hexagonal steel integral with 1-17/32-inch tungsten carbide insert chisel bits. Bunker reported that in the Virgin mine he can drill 800 to 1,000 feet of hole in the harder ground with one piece of steel before the gage of the bit is worn too small for further use. At that time the crown of the insert is worn down only 20 to 35 percent. The life of the steel is prolonged by spotting beads of tube-borium rod on the two gage points of the bit. The bit can then be used only in soft ore, but an additional 80 to 100 feet of hole can be drilled before the beads break off. The process can be repeated until the steel or inserts break.

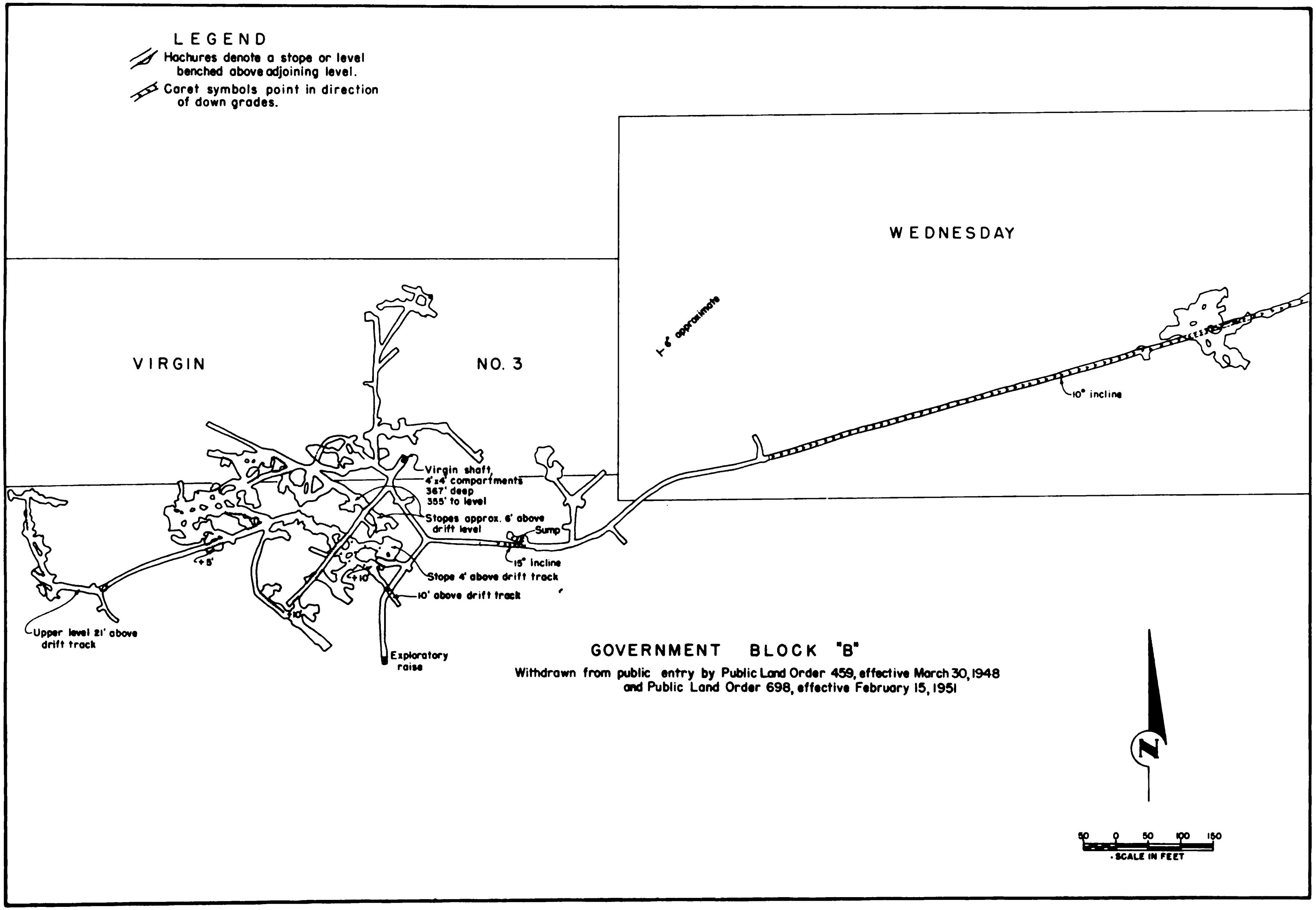

LEGEND
Hochures denote a stope or level benched above adjoining level.
Caret symbols point in direction of down grades.
WEDNESDAY
VIRGIN
NO. 3
1-6° approximate
10° incline
Virgin shaft, 4'x4' compartments 367' deep 355' to level
Stopes approx. 6' above drift level
Sump
15° incline
Stope 4' above drift track
10' above drift track
+10
+10
+5'
Upper level 21' above drift track
Exploratory raise
GOVERNMENT BLOCK "B"
Withdrawn from public entry by Public Land Order 459, effective March 30, 1948 and Public Land Order 698, effective February 15, 1951
N
50 0 50 100 150
SCALE IN FEET

FIGURE 15. - Plan of Virgin Mine.

Original from THE OHIO STATE UNIVERSITY

The usual drift round in hard rock comprises 19 holes; about 16 holes are necessary in soft ore. The cut, a modified four-hole burn, consists of two converging, but not connecting, horizontal holes, with single relievers centered above and below, drilled parallel to the line of advance. Forty-percent semigelatin dynamite is used with standard-delay electric caps in development headings and with regular caps and fuse in stopes.

The ore from the Wednesday ore bodies is slushed to the ore chutes with a 10-horsepower, double-drum, electric-driven hoist and a 36-inch scraper. The hoist is mounted on a timber frame that can be shifted easily to suit the changing stope faces. From the chutes the 18.5-cubic-foot mine cars are hand-trammed to the bottom of the incline, hoisted in three-car trains by a hoistman stationed at the top of the incline (fig. 16), then hauled to the shaft by the motorman with a compressed-air trammer. Nine-inch sideboards on the mine cars increase their heaped capacity to about 30 cubic feet. Mine track is 20-pound rail laid to 18-inch gage.

The Vulcan Denver 17R hoist used at the incline has a single 14-inch-diameter drum and double-post brakes and is driven by a 440-volt, 25-horsepower induction motor. The 1,000-foot length of 1/2-inch hoisting cable must be replaced approximately every 3 months owing to abrasion in the incline. A 2-foot length of 16-pound rail, with one end fastened to the coupling bar on the back of the last car, is used as a safety device when hoisting. The other end of the rail drags along the bottom of the incline to derail and stop the cars if the hoisting cable breaks. (See fig. 17.)

At the shaft the motorman dumps the ore into a 30-cubic-foot-capacity Kimberly-type skip (fig. 18), using a small utility hoist to tip the end-dump cars. Rock from the Wednesday drift is sticky and must be scraped from the cars. The ore is lifted to the surface at approximately 350 f.p.m. with a Vulcan Denver 22R hoist. The single, 24-inch-diameter drum of the hoist is wrapped with 6 by 19, 3/4-inch-diameter cable, has double-post brakes, and is driven by a 50-horsepower induction motor equipped with a thrustor brake.

The A-type, lightweight, structural-steel headframe is 50 feet high. (See fig. 19.) From the skip the ore falls into a small hopper and can be directed by air-operated gates, controlled by the hoistman, into either of two 30-ton-capacity steel ore bins. Waste slides down a chute into a truck. Compressed air is furnished by a Joy WL-80, two-stage, 640-c.f.m. displacement, single-acting, air-cooled stationary compressor. It is driven by a 125-horsepower, 440-volt motor.

The Virgin is wetter than most uranium mines. Water in the lower development headings has made muck handling difficult. A Royal Bean 35 triplex pump, driven by a 10-horsepower electric motor, pumps water to the surface from a 4,000-gallon sump through pipe hung in a 400-foot drill hole. The mine is ventilated by 1,750- to 4,500-c.f.m. surface blowers installed at the collars of 12- and 20-inch churn-drill holes.

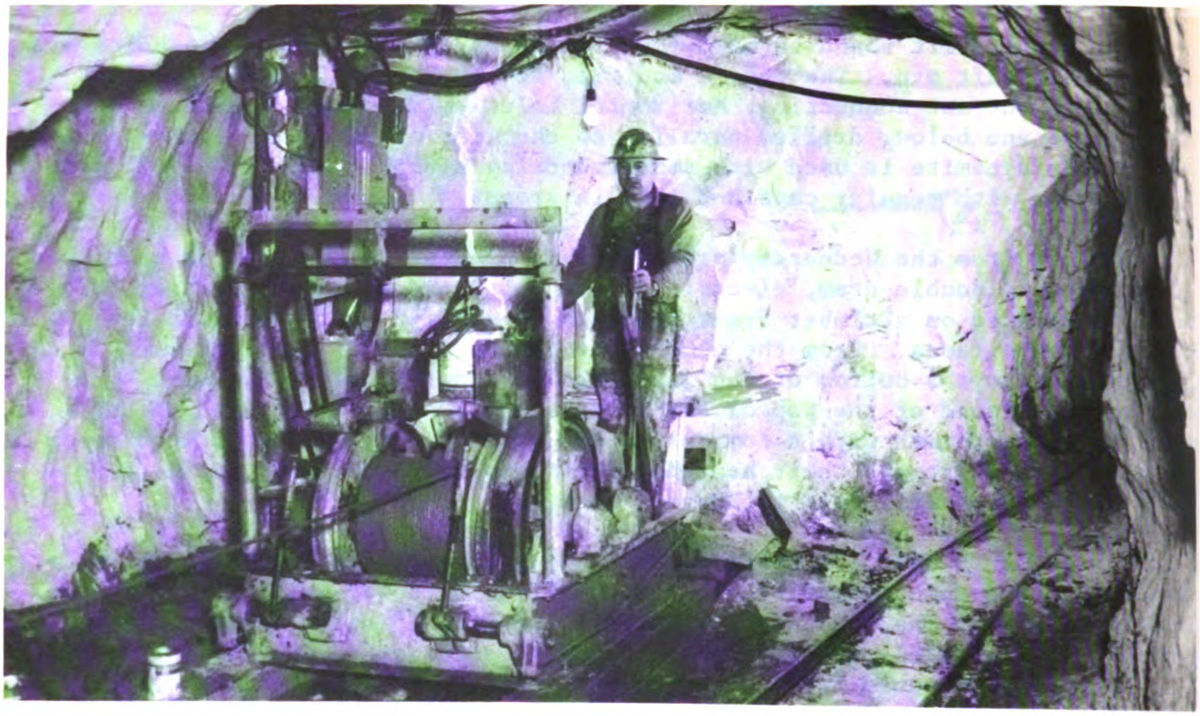


FIGURE 16. - Underground Hoist, Virgin Mine.

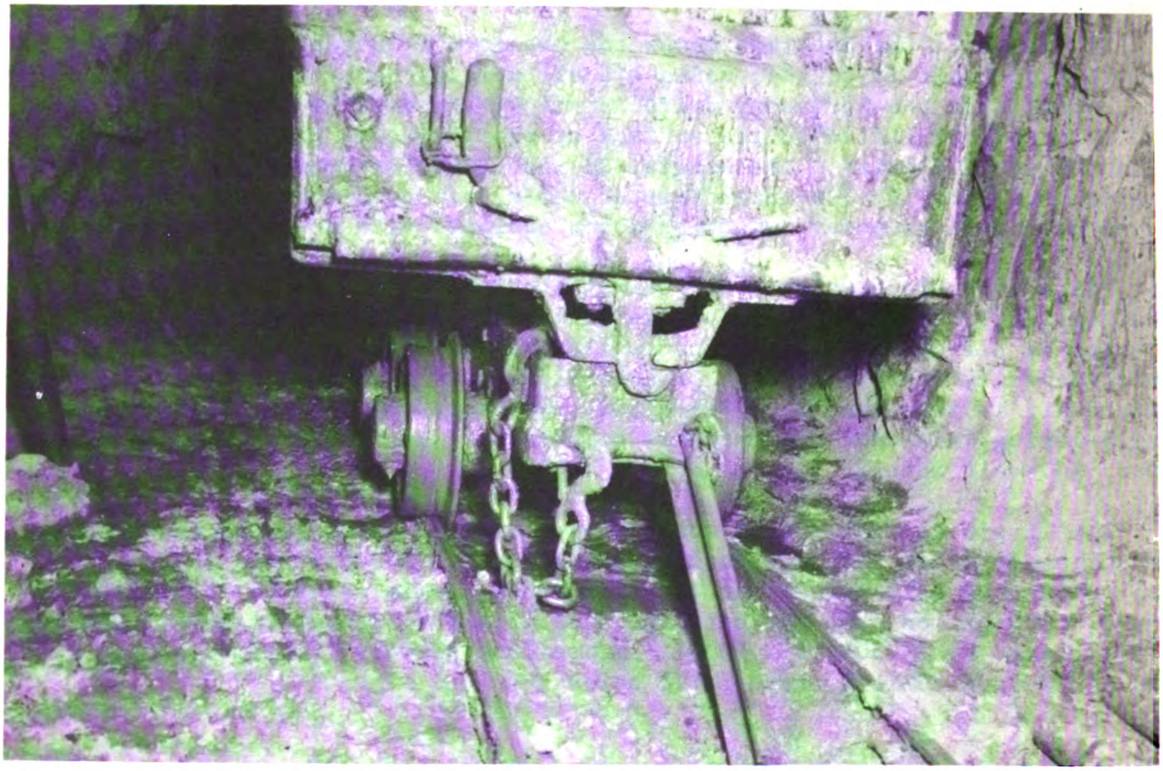
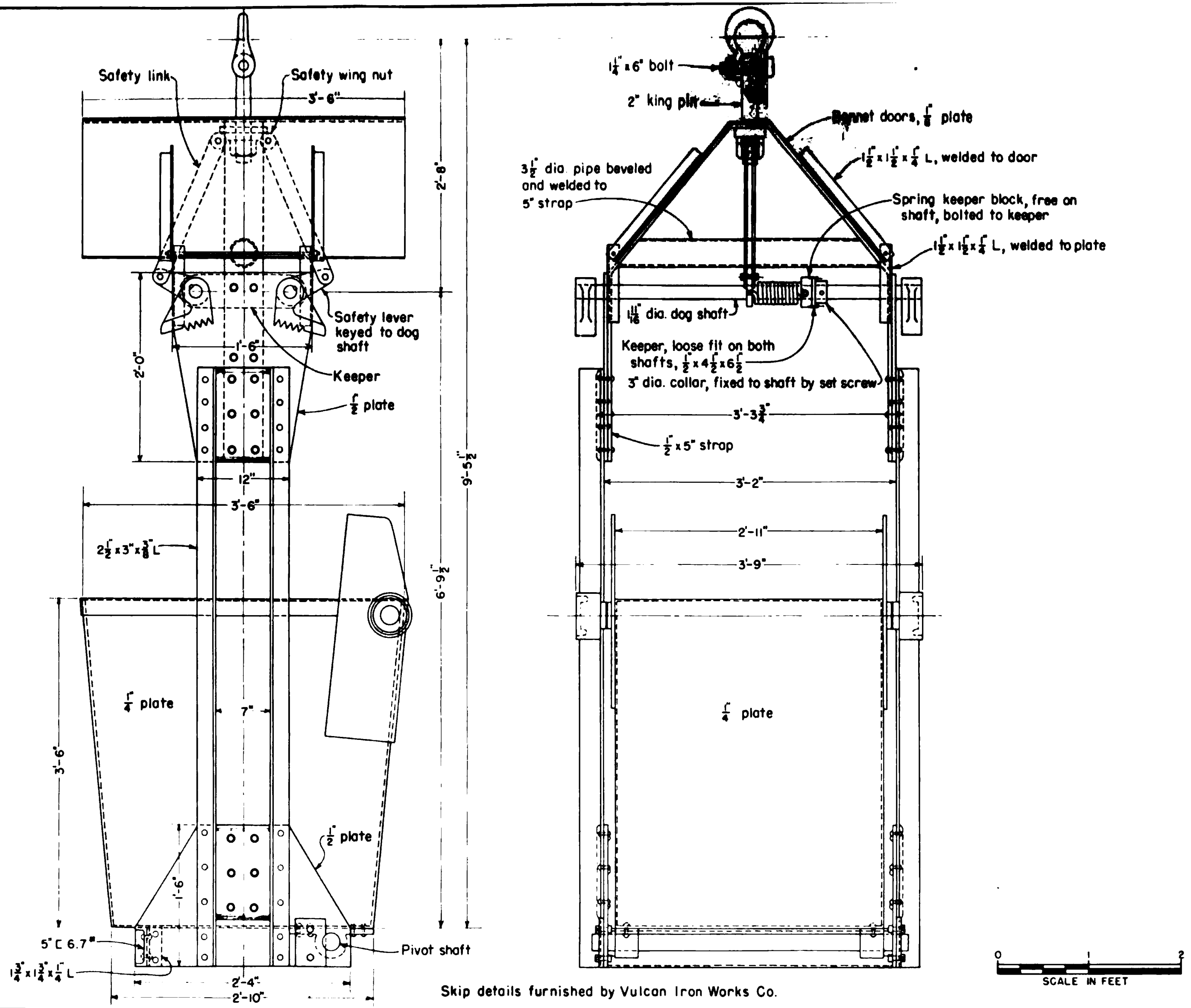
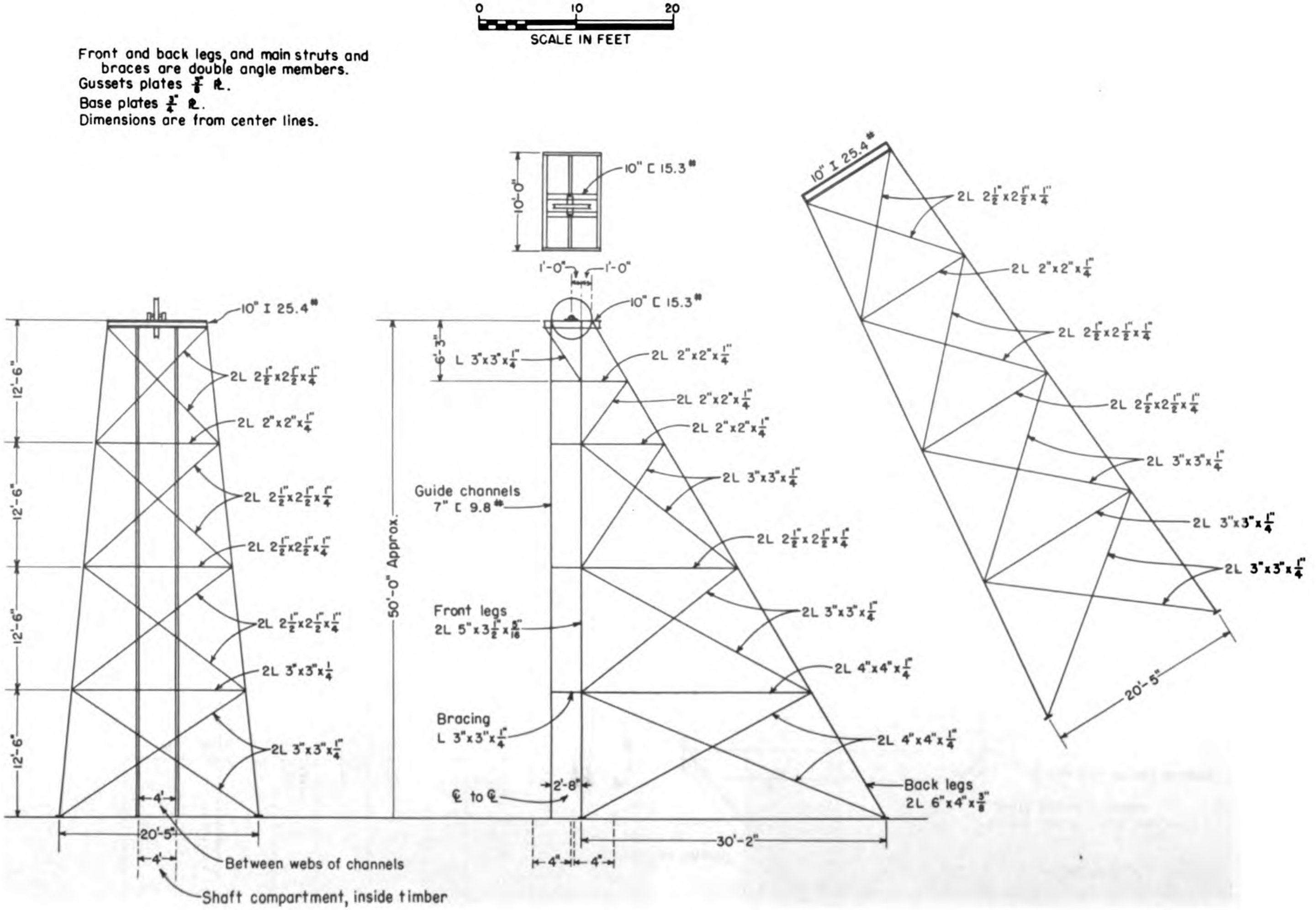


FIGURE 17. - Derailing Device Used When Hoisting in Long Incline, Virgin Mine.



Skip details furnished by Vulcan Iron Works Co.

FIGURE 18. - Design of 30-Cubic-Foot-Capacity Skip Used in Virgin and Guadalcanal Shafts.



Front and back legs, and main struts and braces are double angle members.
Gussets plates $\frac{3}{8}''$ PL.
Base plates $\frac{3}{4}''$ PL.
Dimensions are from center lines.

0
10
20
SCALE IN FEET
10" I 25.4#
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
2L $2''\times2''\times\frac{1}{4}''$
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
2L $3''\times3''\times\frac{1}{4}$
2L $3''\times3''\times\frac{1}{4}''$
12'-6"
12'-6"
12'-6"
12'-6"
4'
20'-5"
4'
Between webs of channels
Shaft compartment, inside timber
10'-0"
10" [15.3#
1'-0"
1'-0"
10" [15.3#
6'-3"
L $3''\times3''\times\frac{1}{4}''$
2L $2''\times2''\times\frac{1}{4}''$
2L $2''\times2''\times\frac{1}{4}''$
2L $2''\times2''\times\frac{1}{4}''$
2L $3''\times3''\times\frac{1}{4}''$
Guide channels
7" [9.8#
50'-0" Approx.
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
Front legs
2L $5''\times3\frac{1}{2}''\times\frac{5}{16}''$
2L $3''\times3''\times\frac{1}{4}''$
2L $4''\times4''\times\frac{1}{4}''$
Bracing
L $3''\times3''\times\frac{1}{4}''$
2L $4''\times4''\times\frac{1}{4}''$
℄ to ℄
2'-8"
Back legs
2L $6''\times4''\times\frac{3}{8}''$
30'-2"
4"
4"
10" I 25.4#
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
2L $2''\times2''\times\frac{1}{4}''$
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
2L $2\frac{1}{2}''\times2\frac{1}{2}''\times\frac{1}{4}''$
2L $3''\times3''\times\frac{1}{4}''$
2L $3''\times3''\times\frac{1}{4}''$
2L $3''\times3''\times\frac{1}{4}''$
20'-5"

Basic details furnished by Grand Junction Steel Fabricating Co.

FIGURE 19. - Basic Design of Virgin and Guadalcanal Headframe.

Ten men are employed at the Virgin mine. Their job classifications and hourly wage scales are as follows:

Job classification	No. of men	Hourly wage
Driller	3	$2.00
Motorman	1	2.00
Mucking-machine operator	1	2.00
Hoistman	1	1.875
Scraper operator	1	1.875
Mucker	2	1.875
Topman	1	1.875

Production during the 7-month cost period, September 1956 to April 1957, averaged 435 tons per month. Ore output for the mine crew, excluding Bunker, averaged 2.0 tons per man-shift. The unit mining costs were computed for a period before electric power was installed.

Equipment used at the Virgin mine comprises the following items:

Number	Equipment item
1	Compressor, 2-stage, 640-c.f.m., Joy WL-80.
1	Hoist, surface, 24-inch single-drum, Vulcan Denver 22R.
1	Hoist, underground, 14-inch single-drum, Vulcan Denver 17R.
4	Drill, airleg-mounted, Ingersoll-Rand JR-38.
1	Locomotive, air, Air Tram.
1	Loader, overhead, Eimco 12B.
1	Scraper hoist, 2-drum, electric, 10-hp., Ingersoll-Rand 10NN-1F.
2	Scraper hoist, 2-drum, air, 8-hp., Ingersoll-Rand HNN-1G.
1	Scraper hoist, 2-drum, air, 7-1/2 hp., Joy FF-211.
1	Tugger hoist, 1-drum, air, 2.3-hp., Ingersoll-Rand D6U.
11	Mine car, 18.5-cu.-ft., end-dump, C. S. Card, low, type Z.
1	Triplex pump, Royal Bean 35; 10-hp., 440-volt motor.
3	Blower, Buffalo and Champion No. 6, 1,750- and 3,500-c.f.m.; gasoline motors.
1	Blower, axial-flow, 4,500-c.f.m., Joy I-21.

Name of mine: Virgin.
Mining method: Open stoping with random pillar support.
Ore mined, tons: 3,054.
Period covered: September 1956 - April 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1/]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2/].......	$1.85	$0.25	$0.39	$0.10	$0.29	$0.05	$0.15	$0.20	$3.28
Mining[3/]............	6.53	.90	.90	.37	1.02	.18	.53	.71	11.14
Total..........	8.38	1.15	1.29	.47	1.31	.23	.68	.91	14.42

2. Indirect cost per ton of ore mined:

Depreciation[4/]..	$1.38
Transportation, men and supplies......................	.13
Social security...	.18
Workmen's compensation insurance.....................	.39
Unemployment compensation............................	.25
Other insurance and taxes............................	.06
Accounting and other..................................	.10
Total...	2.49

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor...	4.0
Total, including supervision....................	4.4
Tons per man-shift:	
Labor...	2.0
Total, including supervision....................	1.8
Explosives, 40-percent semigelatin, pounds per ton...	4.8

[1/] Supervisory cost is not a cash outlay by lessee but an allotted $500 per month ($1.15 a ton) for lessee's supervision.

[2/] Development unit cost, including the supervisory cost of $0.25 per ton, based on "dead-work" payments of lessor.

[3/] Mining costs do not include cost of rail, pipe, timber, etc., furnished by lessor.

[4/] Depreciation of lessee's equipment; does not include depreciation of lessor's mine plant.

Guadalcanal Mine

The shaft-developed Guadalcanal mine is in sec. 27, T. 47 N., R. 17 W., in the Uravan mining district near the center of Long Park. Operating under a lease from Union Carbide Nuclear Co., LaVerne Ray, Formerly of Cripple Creek, Colo., began sinking the Guadalcanal shaft in December 1953. He bottomed the shaft in March 1954 and shipped the first ore in July 1954. The Guadalcanal claim was first located by United States Vanadium Corp. in February 1943.

Ray sank the Guadalcanal shaft 302 feet and cut its single level at 267 feet. The two compartments are 4 by 4 feet in the clear and are open-cribbed with 3- by 8-inch timber set on 8- by 8-inch bearers installed approximately over 20 feet. The positions of the station and headframe relative to the shaft are the same as at the Virgin shaft. The station is simply an 8- by 7-foot haulage drift driven from the end-plate side of the hoisting compartment. The skip faces the station, and 4- by 6-inch guides are fastened to the wall plates. An A-type headframe was erected over the collar, with the bent of the front posts at a right angle to the long axis of the shaft compartments.

The general strike of the beds in the Guadalcanal mine is about N. 40° W. and their dip about 6° NE. The shaft was sunk centrally between two mineralized areas that are about 500 feet apart in a northwest-southeast direction and are 190 to 310 feet below the surface. (See fig. 20.) The northwest ore bodies are updip and about 20 feet higher than those to the southeast. The main level cuts the major ore bodies at or above track level, and the stopes are benched from 3 to 7 feet above the track in the 6- by 7-foot haulage drifts. Ray keeps as much of his development work within the ore zones as possible. Where the ore bodies are about 15 feet above track level, they are opened through short raw raises; where the ore is 20 feet or more above track level, inclines are driven to the ore zone. The ore mined through 1957 averaged about 4 feet in thickness and had a maximum thickness of approximately 7 feet.

The rock overlying much of the ore is weaker than that overlying most Salt Wash ore deposits. The mudstone overlying the southeast ore bodies sloughs easily, and stulls are necessary to keep some workings safe. Drift sets are needed in headings driven beneath the ore zone in sugary, poorly consolidated sandstone.

The rock is drilled with leg-mounted drills, 7/8-inch hexagonal steel, and 1-5/8-inch one-use socket bits. The usual drift round consists of 17 holes, including a five-hole burn cut, the center hole of which is not loaded. As few as 12 holes, which can be drilled in about 1 hour, will break the poorly consolidated sandstone. The ground is broken with 1- by 8-inch cartridges of 30-percent semigelatin dynamite. Rock broken in drift headings is loaded with Eimco 12B RockerShovels. Five-horsepower, air-driven, double-drum slusher hoists with 24-inch scrapers are used to load ore from stopes at or below track level into mine cars placed under timber ramps. The hoists also pull the ore from stopes benched above track level directly into the haulage drifts. A 10-horsepower, double-drum, electric-driven hoist with a 36-inch scraper is used when driving inclines and in stopes where the haul exceeds 100 feet.

The ore is hand-trammed to the shaft station in 18.5-cubic-foot-capacity end-dump mine cars that run on 12-pound rails laid to 18-inch gage. The single, 30-cubic-foot, Kimberly-type skip (fig. 18) is hoisted about 350 f.p.m. by a Vulcan Denver 22R mine hoist, like the hoist used at the Virgin shaft. The headframe and dumping device are also similar to those used at the Virgin. (See figs. 19 and 21.)

Compressed air is furnished by a vertical, two-stage, air-cooled, 465-c.f.m., Chicago Pneumatic PB-8, stationary compressor, driven by a 100-horsepower induction motor, and a vertical, two-stage, 230-c.f.m., water-cooled, Gardner-Denver WBQ compressor, driven by a 50-horsepower induction motor.

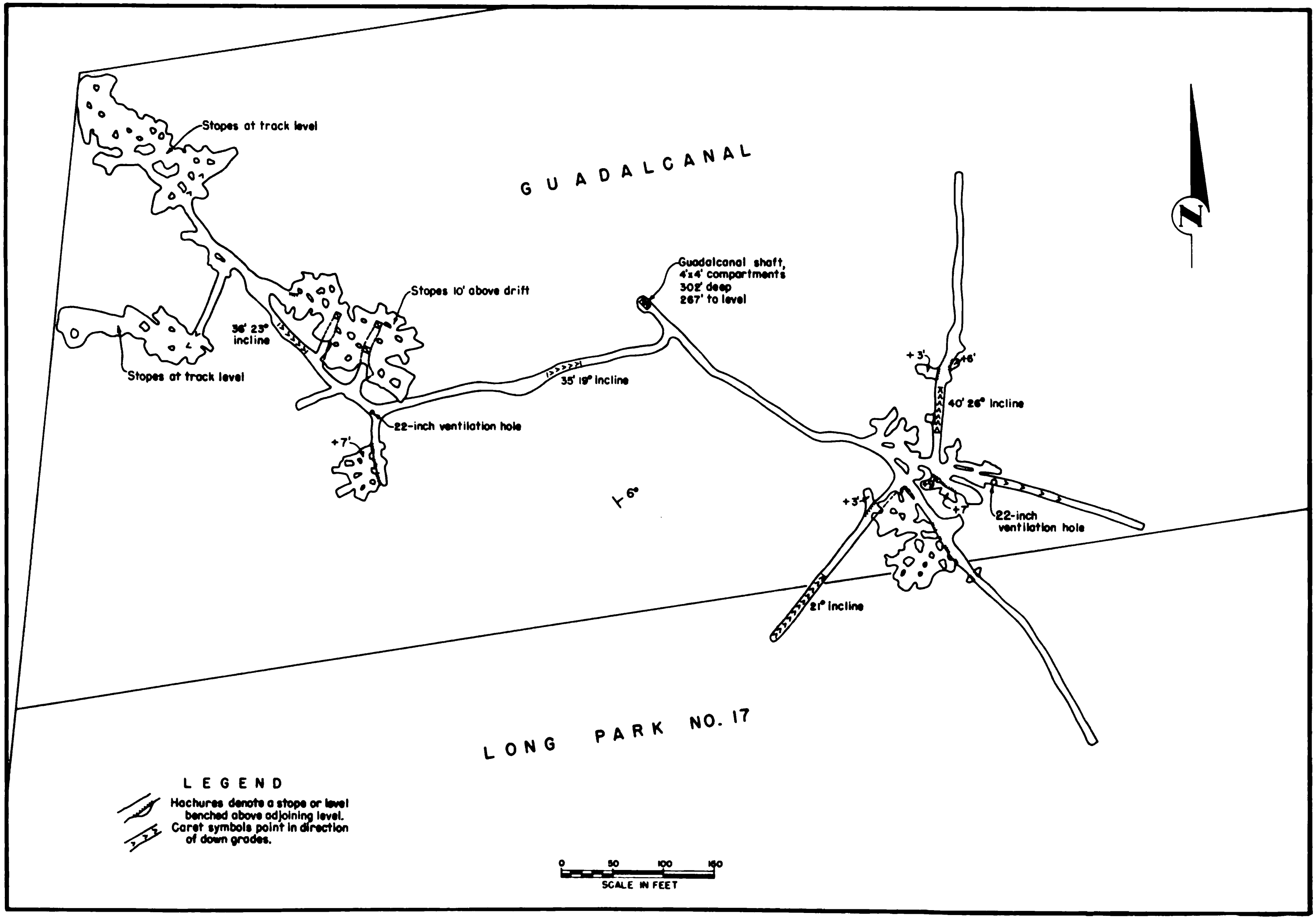


FIGURE 20. - Plan of Guadalcanal Mine.

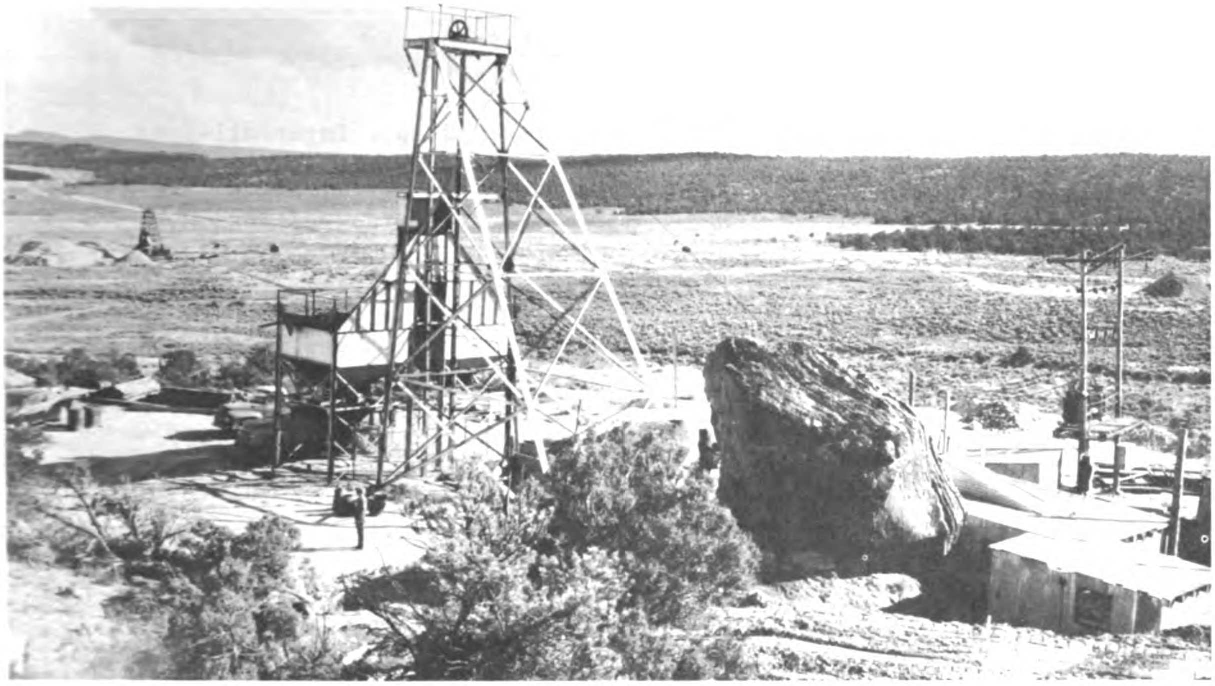


FIGURE 21. - Guadalcanal Headframe Looking South Across Long Park.

The newly erected lines of San Miguel Power Association, Inc., carry electric power at 13,700 volts to the transformers at the mine. Mining costs cover a 15-month period before conversion to electric power.

The mine is ventilated by three electric-driven, 4,500-c.f.m., axial-flow intake blowers. Two, installed underground at 22-inch-diameter churn-drill holes, blow fresh air to the working faces through flexible ventilation tubing. A similar fan, installed at the collar of the shaft, blows fresh air into the mine through ventilation tubing hung in the manway compartment.

Monthly production for the 15-month cost period, January 1956 to April 1957, averaged 455 tons. Productivity for all labor and supervision was 2.3 tons per man-shift.

Equipment used at the Guadalcanal mine comprises the following items:

Number	Equipment item
1	Compressor, 465-c.f.m., stationary, Chicago Pneumatic PB-8; 100-hp. induction motor.
1	Compressor, 230-c.f.m., stationary, Gardner-Denver WBQ; 50-hp. induction motor.
1	Hoist, single-drum, Vulcan Denver 22R; 100-hp. induction motor.
6	Drill, airleg-mounted, Ingersoll-Rand J40 with JL-4 leg, Atlas Copco BBC-22, Cleveland H10AL.

Number	Equipment item
2	Loader, overhead, Eimco 12B.
1	Scraper hoist, 2-drum, electric, 10-hp., Ingersoll-Rand 10NN-1F.
3	Scraper hoist, 2-drum, air, 5-hp., Ingersoll-Rand A5NN-OH.
5	Tugger hoist, 1-drum, air, 7-1/2-hp., Ingersoll-Rand HU.
5	Mine car, 18.5-cu.-ft., C. S. Card, low, type Z.
3	Fan, axial-flow, 4,500-c.f.m., Joy I-21.

Name of mine: Guadalcanal.

Mining method: Open stoping with random pillar support.

Ore mined, tons: 6,831.

Period covered: January 1956 - April 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1/]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2/].......	$0.86	$0.16	$0.12	$0.04	$0.10	$0.09	$0.14	$0.08	$1.59
Mining[3/]............	5.14	.94	.72	.21	.62	.54	.84	.45	9.46
Total..........	6.00	1.10	.84	.25	.72	.63	.98	.53	11.05

2. Indirect cost per ton of ore mined:

Depreciation[4/]...	$0.47
Transportation, men and supplies......................	.25
Social security..	.12
Workmen's compensation insurance......................	.22
Unemployment compensation.............................	.11
Other insurance and taxes.............................	.05
Accounting and other..................................	.04
Haulage..	.12
Total..	1.38

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor..	3.0
Total, including supervision......................	3.5
Tons per man-shift:	
Labor..	2.7
Total, including supervision......................	2.3
Explosives, 30-percent semigelatin, pounds per ton.....	3.1

1/ Supervisory cost is not a cash outlay by lessee but an allotted $500 per month ($1.10 per ton) for lessee's supervision.

2/ Development unit costs, including the supervisory cost of $0.16 per ton, based on "dead-work" payments of lessor.

3/ Mining costs do not include cost of rail, pipe, timber, etc., furnished by lessor.

4/ Depreciation of lessee's equipment; does not include depreciation of lessor's mine plant.

Hummer and Oversight Mines

The adjoining Hummer and Oversight mines are in sec. 21, T. 46 N., R. 17 W., Bull Canyon mining district, Montrose County, Colo. The mines are 6,250 to 6,340 feet above sea level on the northeast wall of Monogram Mesa. They are about 1,000 feet above the floor of Paradox Valley and about 600 feet below the mesa rim. Paradox Valley trends northwesterly and is about 3 miles wide at this point. Long Park lies behind the rimrock on the opposite side of the valley.

The Hummer and Oversight mines are in part of a large mineralized zone known as the Jo Dandy deposit. This unusually large deposit is in the upper sandstone unit of the Salt Wash and is continuous but poorly defined for 3,000 feet along its outcrop.[21/] The ore mined to date has ranged in thickness from a few inches to nearly 20 feet. Ore mined during the 15-month cost period, January 1956 to April 1957, averaged about 6 feet in thickness. The Jo Dandy deposit consists of three main shingled layers of ore minerals. Interconnecting or overlapping layers form the thickest ore. The large ore body developed through the south Hummer adit is composed of two overlapping layers. The upper layer is usually separated from the lower, more massive, low-grade layer by barren sandstone. The upper ore is 3 to 5 feet thick, is rich and podlike, and terminates abruptly. The lower ore is more tabular and appears to be in sandstone that has more regular bedding; its limits are poorly defined. Gypsum impregnates the sandstone, cementing the grains and filling fractures.

The extensive zone of faulting along the southwest flank of the collapsed Paradox Valley anticline cuts through the Jo Dandy ore and offsets it as much as 60 feet. The fault blocks are dropped progressively toward the valley. The general strike of the beds on the southwest flank of the anticline is northwest, but in the faulted blocks containing the Hummer, Oversight, and Jo Dandy ore bodies the strike of the beds is principally northeast.

The Jo Dandy claim was first located in 1906 by Joseph Good, the Oversight claim in 1906 by N. I. Westerfield, and the Hummer claim in 1909 by A. J. Talbert. The region formerly was part of the area called the Paradox district, and the spur extending into the valley from Monogram Mesa was called Pinon Point. General Vanadium Co. of America, Baltimore, Md., a subsidiary of International Vanadium Co., Liverpool, England, acquired the Hummer and Jo Dandy claims late in 1909[22/] and located the Broker claims in 1911. Hess reported that the mine was worked in 1910 and 1911 for vanadium ore, which was shipped to England.[23/] By 1913 General Vanadium Co. owned 58 claims in Paradox Valley and the surrounding districts.[24/] In June 1913 Standard Chemical Co. purchased

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[21/] Cater, F. W., Jr., Geology of the Bull Canyon Quadrangle, Colorado: Geol. Survey Quadrangle Map GQ 33, 1954.

[22/] Curran, T. F. V., Carnotite I: Eng. Min. Jour., vol. 96, No. 25, 1913, pp. 1165-1167.

[23/] Hess, F. L., New and Known Minerals From the Utah-Colorado Carnotite Region: Geol. Survey Bull. 750, 1923-24, p. 64.

[24/] Moore, R. B., and Kithil, K. L., A Preliminary Report on Uranium, Radium, and Vanadium: Bureau of Mines Bull. 70, 1916, p. 103.

the claims. In 1916 the Jo Dandy mine was thought to have been worked out,2 but in 1918 Standard Chemical found additional reserves by underground prospecting. Burros were used to pack the ore from the Jo Dandy mine down the Monogram rim trail to the stage road in Paradox Valley, about 1,000 feet bel where it was transferred to wagon freighters. The cost of packing was from $2 to $3 a ton. Water packed up to the camp cost $1.25 a barrel. Freightin by wagon to the railpoint at Placerville, Colo., cost $18 a ton. Standard closed down the Jo Dandy mine in 1921. United States Vanadium Corp. acquire the claims in 1928 and worked the Jo Dandy mine for vanadium from 1937 to 19 The United States Vanadium Corp. discovered large ore reserves on the Hummer claim southeast of the Jo Dandy mine by a drilling program begun in 1943. T south Hummer adit was driven from the rim to develop the new reserves and establish a connection with the Jo Dandy workings, but work on the adit was stopped and little mining done after the wartime need for vanadium waned. Th mines were idle again from 1944 to 1948. Lowell Staats began operating them under a lease contract in October 1948, mining through the south Hummer adit. In 1955-56 he drove the north adit to develop the downfaulted part of the ore body. Under his present lease agreement with Union Carbide Nuclear Co., Staats leases the Hummer, Oversight, and Broker claims. His largest output has come from the Hummer claim. As mining progressed, additional ore was found by underground and surface exploratory drilling. The old Jo Dandy mine was worked sporadically by lease contractors from 1948 to 1953.

The two Hummer adits and the Oversight adit were driven southerly from points on the canyon wall at elevations that have permitted stoping the major ore bodies at or above track level. (See fig. 22.) Proved ore extensions beneath the principal levels have been developed through inclines. The cost of hoisting and lowering mine cars through the inclines adds to the total labor costs, but in the opinion of company officials this additional cost is offset by the advantage of keeping the main levels in the ore strata.

The portal of the north Hummer adit is 300 feet northwest of and 62 feet lower than the portal of the south Hummer adit (fig. 23) and is in the downfaulted segment of the ore body. The fault that caused this block to drop strikes northwesterly and passes in front of the upper portal. The north Hummer adit is the ore-haulage level of the Hummer mine. The ore produced from the upper workings is dropped through a two-compartment timbered raise to the lower level and hauled to the bins. The dip of the ore in the lower adit is about 10° southerly. The ore beds in some of the large stopes in the upper Hummer adit are almost horizontal, but some ore dips as much as 8° SE.

The Oversight adit is lower than the Hummer adits; its portal is 570 feet east of and 85 feet lower than the south Hummer adit. The adit penetrates ore bodies in what appears to be the same fault block as that in which the upper Hummer ore bodies are found. The general dip of the beds in the Oversight workings is southeast. Minor faulting and changes in the dip of the ore can be seen in the main Oversight workings.

25/ Coffin, R. C., Radium, Uranium, and Vanadium Deposits of Southwestern Colorado: Colorado Geol. Survey Bull. 16, 1921, p. 207.

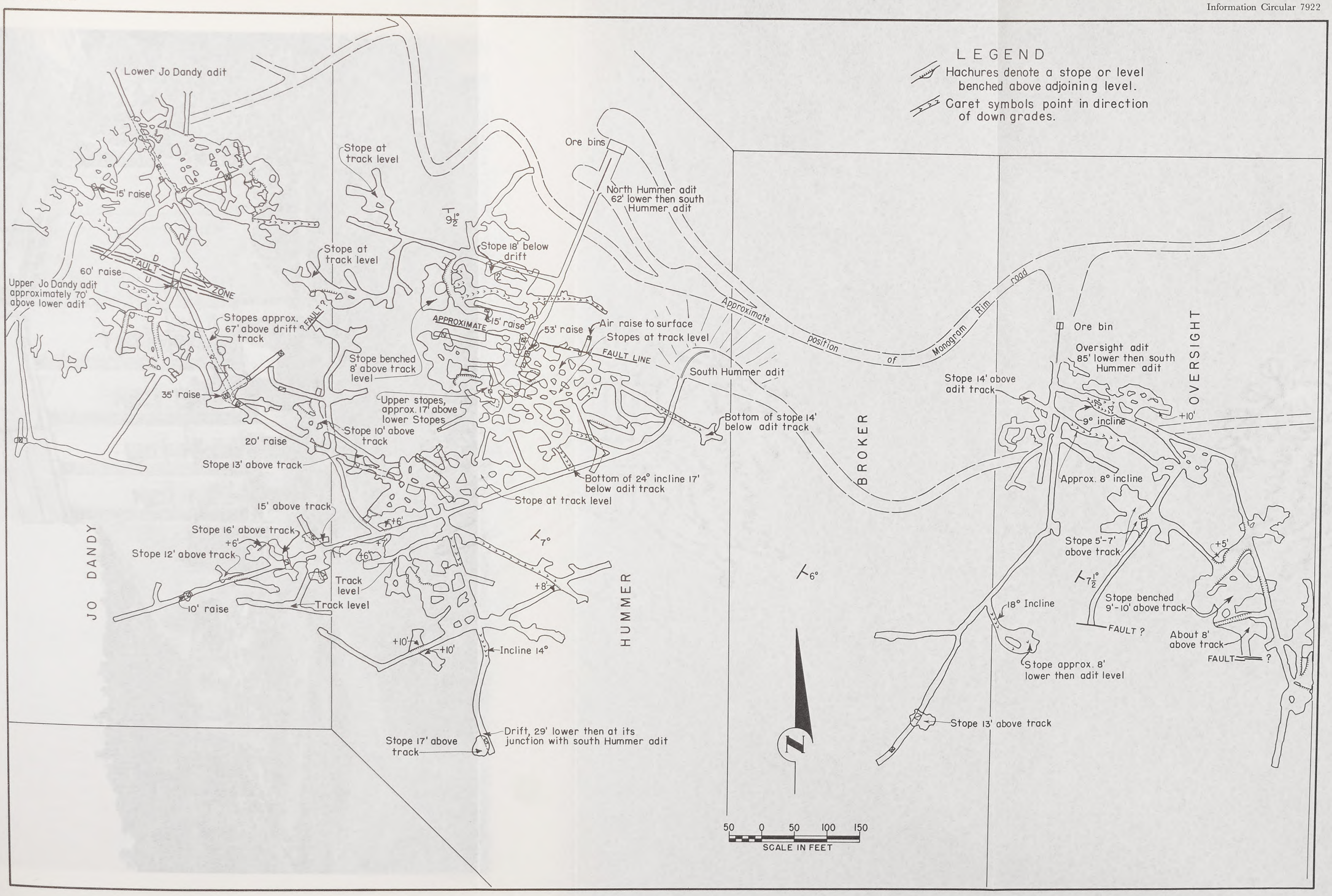
LEGEND
Hachures denote a stope or level benched above adjoining level.
Caret symbols point in direction of down grades.
Lower Jo Dandy adit
15' raise
60' raise
FAULT
ZONE
D
U
Upper Jo Dandy adit approximately 70' above lower adit
Stopes approx. 67' above drift track
FAULT ?
35' raise
20' raise
Stope 13' above track
15' above track
Stope 16' above track
+6'
Stope 12' above track
10' raise
Track level
Track level
+6'
+7'
+6'
+10'
+10'
Incline 14°
+8'
Stope 17' above track
Drift, 29' lower then at its junction with south Hummer adit
JO DANDY
HUMMER
Stope at track level
Stope at track level
9½°
Stope 18' below drift
APPROXIMATE
15' raise
53' raise
Air raise to surface
Stopes at track level
FAULT LINE
Stope benched 8' above track level
Upper stopes, approx. 17' above lower Stopes
Stope 10' above track
Bottom of 24° incline 17' below adit track
Stope at track level
7°
Ore bins
North Hummer adit 62' lower then south Hummer adit
South Hummer adit
Bottom of stope 14' below adit track
Approximate position of Monogram Rim road
BROKER
6°
N
50 0 50 100 150
SCALE IN FEET
Ore bin
Oversight adit 85' lower then south Hummer adit
OVERSIGHT
Stope 14' above adit track
9° incline
+10'
Approx. 8° incline
Stope 5'-7' above track
7½°
+5'
Stope benched 9'-10' above track
18° Incline
FAULT ?
About 8' above track
FAULT ?
Stope approx. 8' lower then adit level
Stope 13' above track

FIGURE 22. - Plan of Jo Dandy, Hummer, and Oversight Mines.

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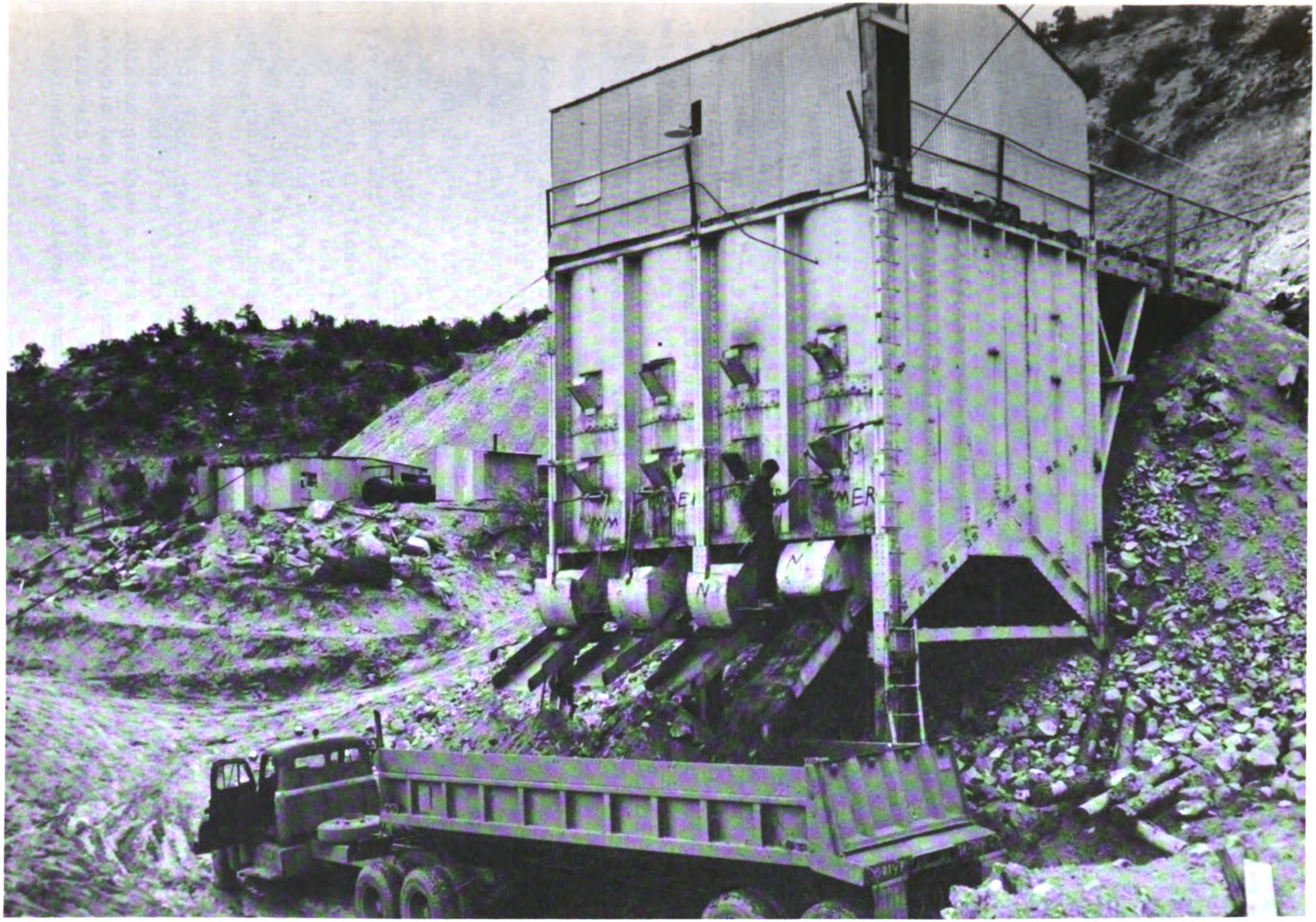

FIGURE 23. - Loading Ore Truck From North Hummer Bin.

The old Jo Dandy mine was developed by early miners through a number of adits driven into the ore outcrops on both the upthrown and downthrown parts of the deposit. A haulage drift driven from the lower Jo Dandy workings crosses the fault and is connected with the upper Hummer level by a raise similar to the one connecting the lower and upper Hummer workings. The workings of the Hummer and Oversight mines are not connected yet, but drifts are being driven on haulage grade from the Oversight mine to develop the ore between the mines. The stoping level will be above the haulage level, and the ore will be mined through raises.

Haulageways at the Hummer and Oversight mines are driven with a minimum cross section of 6 by 7 feet to accommodate mechanical muckers. The haulageways are untimbered, except where they cross fractured and faulted ground. The north Hummer adit, which was driven through the fault zone and the unconsolidated slump material that borders it, is timbered for its entire length with sets of 8- by 8-inch timbers, set to provide 7-1/2 feet of headroom.

Staats practices "good housekeeping" at his mines. The haulageways are clean and well lighted, and the track is well tied and ballasted. Twenty-pound rail is used in the lower Hummer and Oversight adits, and 16-pound rail is used in the upper Hummer adit.

Where the sandstone has been subjected to extensive oxidation, as in the lower Hummer workings, it is more friable and easier to break. Usually, the brightly colored ore minerals are found in the softer and more oxidized rocks, and sometimes the high-grade ore has an almost earthy feel. In soft, oxidized ground, Staats uses a 40-percent semigelatin dynamite. In ground containing the black ores, where the rock is usually better cemented, Staats uses a 45-percent dynamite.

Rounds are drilled with leg-mounted rock drills and 7/8-inch hexagonal steel. The miners prefer one-use, four-wing, socket-type bits. They report that the best drilling results are obtained with the Ingersoll-Rand, one-use, 1-3/4-inch Sandbit and the Liddicoat one-use bit with an upset pilot. The miners reported a drilling performance of approximately 400 feet with the Liddicoat Tee Cee, four-wing, insert, socket-type bit. They have found that the tungsten carbide insert chisel bit loses gage quickly in ground of this type. Like most Salt Wash miners, Staats prefers to break out the softer ore first if selective mining is necessary. Heading rounds, wholly in ore, are drilled to break 18 to 22 tons, and stope rounds are drilled to break 30 to 35 tons. To maintain an output of 1,500 to 1,900 tons of ore a month from the two mines, Walt Campbell, foreman, reported that enough ore must be opened so that three to four drillers can be assigned to ore headings each day. An average of two drillers is kept in development headings.

In stopes above track level the ore is moved by 5-horsepower, double-drum, air-driven slusher hoists to either timbered ore chutes or (from bench stopes) is dropped onto the track and loaded into cars with a mucking machine. All ore mined on the upper Hummer level is hand-trammed (fig. 24) and dropped to the north Hummer level through the main ore raise. An Eimco 401 air-driven locomotive is used to pull ore cars on the lower Hummer level. A Mechanics

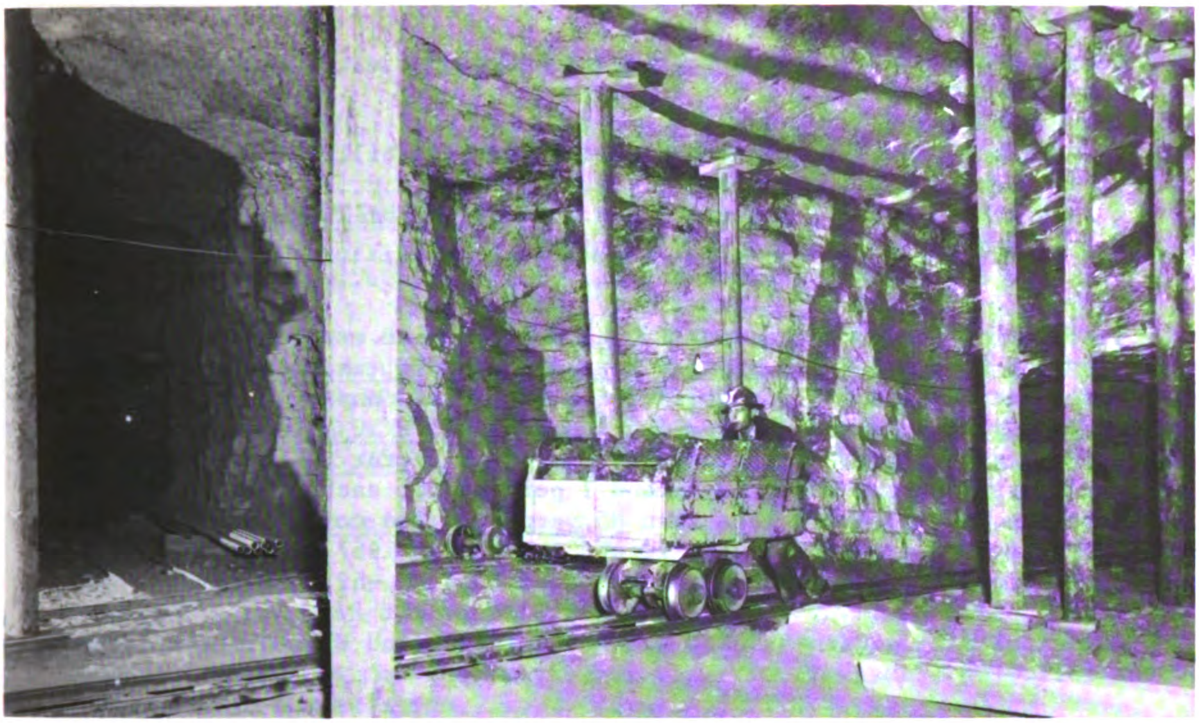

FIGURE 24. - Hand Tramming, Hummer Mine.

Service Co. Air Tram locomotive, made in Cripple Creek, Colo., is used on the upper level to transport waste to the portal. At the Oversight, the mine cars are hand-trammed to the surface.

Production had increased from about 300 tons of ore a month during the first part of 1956 to about 1,900 tons a month in March 1957. To produce the March 1957 tonnage, Staats employed 27 men 5 days a week, 8 men and 1 working shift boss being assigned to each of the two Hummer levels and to the Oversight mine. In 1956 and the first quarter of 1957 3.1 tons of ore was produced per man-shift of labor. Drillers, loading-machine operators, and trammers earn $2.00 per hour; other workers earn $1.85 per hour.

Compressed air is furnished by two 550-c.f.m., Garnder-Denver WBJ stationary compressors, each driven by 125-horsepower, 440-volt motors installed in a prefabricated light-steel building. Compressed air is delivered to the mine entries through 3-inch, split-ring-coupled pipe reduced to 2-inch pipe underground. In August 1956 electric power was supplied through the newly erected lines of the San Miguel Power Association, Inc., Nucla, Colo., which delivers it at 13,700 volts to the transformers at the mine. The 1957 power-cost schedule of the San Miguel Power Association, Inc., follows:

Demand Charge: Per kilowatt of maximum demand	$1.50
Energy Charge:	
First 50 kw.-hr. per month per kilowatt of billing demand	.03
Next 100 kw.-hr. per month per kilowatt of billing demand	.02
All additional kilowatt-hours	.014

The billing demand is the maximum kilowatt demand established by the consumer for any 15 consecutive minutes during the month, as recorded by the demand meter and adjusted for power factor. The power company reserves the right to adjust the demand charge, for consumers with 50 kilowatts or more of measured demand per month and whose average power factor is lower than 85 percent, by increasing the measured demand 1 percent for each 1 percent by which the average power factor is less than 85 percent. The cost for power at the Hummer-Oversight operation for the first 3 months of 1957 averaged $0.46 per ton of ore produced, and consumption averaged 13.5 kw.-hr. per ton.

Principal mine equipment used at the Oversight and Hummer mines consists of the following items:

Number	Equipment item
2	Compressor, 550-c.f.m., stationary, Gardner-Denver WBJ; 125-hp., electric motor.
9	Drill, airleg-mounted, Cleveland H10AL.
18	Mine car, end-dump, 18.5-cu.-ft., C. S. Card, low, type Z.
2	Locomotive, air, Eimco 401 and Mechanics Service Co. Air Tram.
4	Loader, overhead, Eimco 12B.
4	Scraper hoist, 2-drum, air, 5-hp., Ingersoll-Rand A5NN-OH.
9	Tugger hoist, 1-drum, air, 7-1/2-hp., Joy F-112 and Ingersoll-Rand HU.
4	Blower, axial-flow, 4,500-c.f.m., Joy I-21.

Name of mines: Hummer and Oversight.

Mining method: Open stoping with random pillar support.

Ore mined, tons: 15,526.

Period covered: January 1956 - April 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1]	Explosives	Drill steel and bits	Fuel oil, gas, elec.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2]......	$0.92	$0.10	$0.13	$0.05	$0.10	$0.08	$0.01	$0.02	$1.41
Mining[3]...........	4.33	.48	.63	.24	.45	.36	.07	.11	6.67
Total.........	5.25	.58	.76	.29	.55	.44	.08	.13	8.08

2. Indirect cost per ton of ore mined:

Depreciation[4]..	$0.63
Transportation, men and supplies.......................	.11
Social security..	.10
Workmen's compensation insurance.......................	.18
Unemployment compensation..............................	.13
Other insurance and taxes..............................	.10
Accounting and other...................................	.05
Total..	1.30

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor..	2.6
Total, including supervision.........................	2.8
Tons per man-shift:	
Labor..	3.1
Total, including supervision.........................	2.9
Explosives, 40- and 45-percent semigelatin, pounds per ton..	2.8

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[1] Supervisory cost is not a cash outlay by the lessee but an allotted $600 per month ($0.58 per ton) for lessee's supervision.

[2] Development unit costs, including the supervisory cost of $0.10 per ton, are based on "dead-work" payments by lessor.

[3] Mining costs do no include rail, pipe, timber, etc., furnished by lessor.

[4] Depreciation of lessee's equipment.

Dorothy Jean No. 1 Mine

The Dorothy Jean No. 1 mine is in sec. 18, T. 46 N., R. 17 W., Bull Canyon mining district, on Monogram Bench. Monogram Bench is the gently sloping area between the higher Monogram Mesa to the southeast and Davis Mesa to the northwest. The mine is about 2 miles northwest of the Jo Dandy mine on the same wall of Paradox Valley; the altitude of its portal is about 6,585 feet. The Salt Wash member of the Morrison formation, which at that point dips about 3°

SW., forms the surface of the Uranus and Dorothy Jean No. 1 claims. The mine is southwest of the main belt of block faulting that forms the southwest wall of Paradox Valley, but large fractures that are part of the fault system are exposed in the mine workings. The ore contains the brightly colored oxidized uranium-vanadium minerals and has averaged about 5-1/2 feet in thickness.

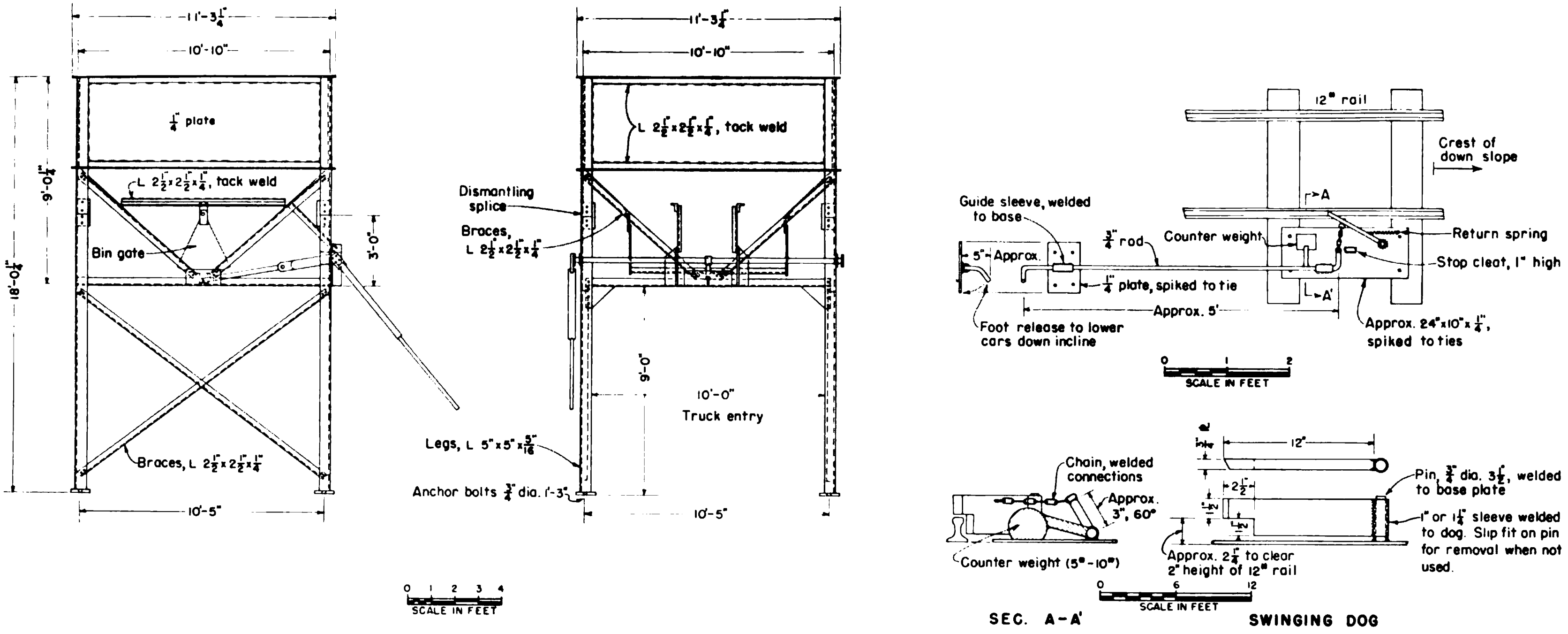
The Uranus claim was located in the early days by Standard Chemical Co. The Dorothy Jean No. 1 claims was located in April 1948 by United States Vanadium Corp. Carl Tucker of Grand Valley, Colo., began sinking the Dorothy Jean incline in March 1957 and producing ore early the following May. Therefore, the period of ore production was too short for representative costs to have been established when information for this report was being gathered. However, because Tucker had kept accurate cost records for his two previous Salt Wash lease operations and because of his competence in Salt Wash mining, it was decided to include in this report a brief description of mining at the Dorothy Jean and the record of costs incurred at his two previous leases during the 14-month period before March 1957.

Tucker sank the 6- by 7-foot Dorothy Jean No. 1 incline on a 26° dip, southwesterly from a bench on the mesa slope, a short distance below the rim. The incline is 85 feet long and is timbered and top-lagged for the first 45 feet. Before Tucker began sinking, he mounted a small, double-drum, gasoline-driven hoist on a short trestle framed to the height of his 30-ton steel ore bin. (See fig. 25.) The rock excavated in sinking was slushed with a 30-inch scraper to form a rock slope between the portal of the incline and the trestle, on which track was laid to the top of the bin.

From the bottom of the incline, which is 18 feet below the ore zone, 6- by 7-foot haulage drifts were being driven 600 to 700 feet northwest and southeast through a series of ore bodies lying roughly parallel to the mesa rim. The drifts intersect the ore bodies above track level and the stopes are benched out from the drifts. Drift timbering is necessary where open fractures are crossed.

The ore is drilled with airleg-mounted drills, using 7/8-inch hexagonal steel in 5-foot lengths and hard-surfaced one-use-type bits. Tucker prefers the tube-borium hard-surfaced bits, which cost $1.35 each when purchased in lots of 50 or more. Standard heading rounds, comprising 17 reliever and trim holes surrounding a four-hole burn cut (fig. 26), are broken with 40-percent semigelatin dynamite. The broken ore is scraped with 5-horsepower, double-drum, air-driven slusher hoists and 30-inch scrapers from the bench stopes into the drifts (fig. 27), where it is loaded into mine cars with an overhead loader. The cars are hand-trammed to the incline over 16-pound rail laid to 18-inch gage and hoisted to the ore bin by the small single-drum hoist (fig. 28).

Under his lease, Tucker is required to produce 500 tons of ore a month from this high-grade deposit. He employs four men and pays a base hourly wage of $2.00. He awards men that have been with him a year or longer a bonus of $0.50 per ton of ore hoisted.



30-TON STEEL ORE BIN

SIMPLE SAFETY DEVICE TO HOLD MINE CARS AT THE TOP OF AN INCLINE

FIGURE 25. - Ore Bin (30-Ton) and Incline Safety Device Used at Union Carbide Nuclear Co. Mines.

Original from THE OHIO STATE UNIVERSITY

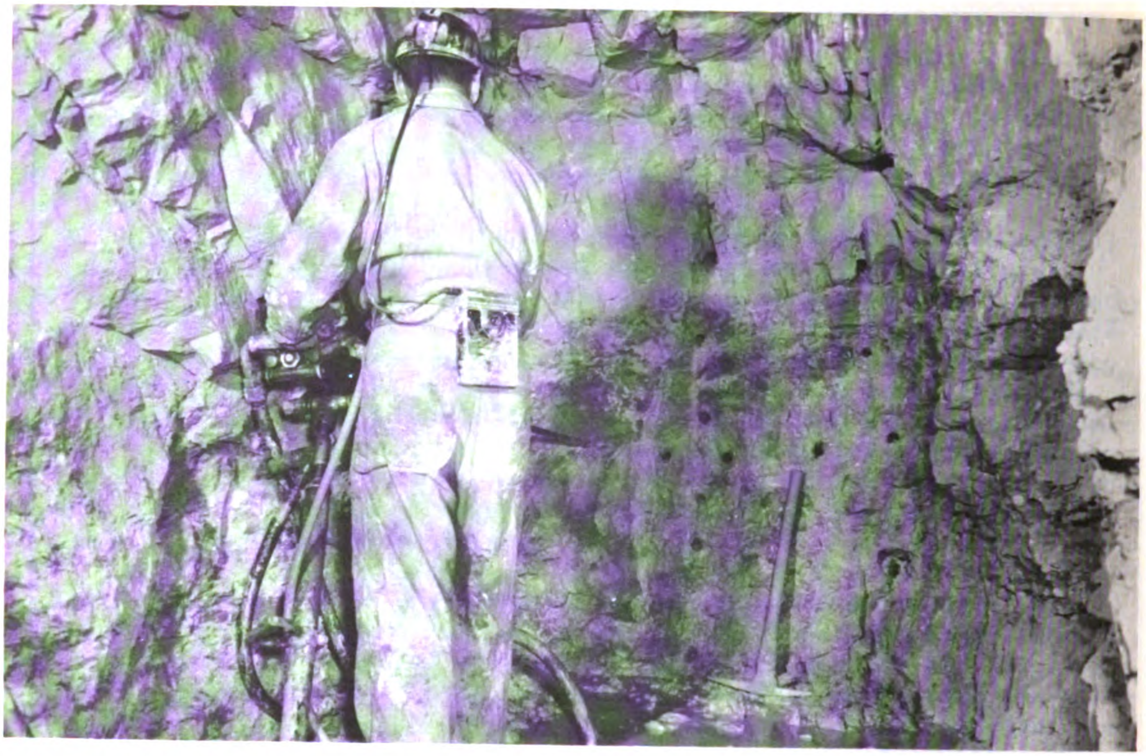


FIGURE 26. - Drilling Heading Round, Dorothy Jean No. 1 Mine.

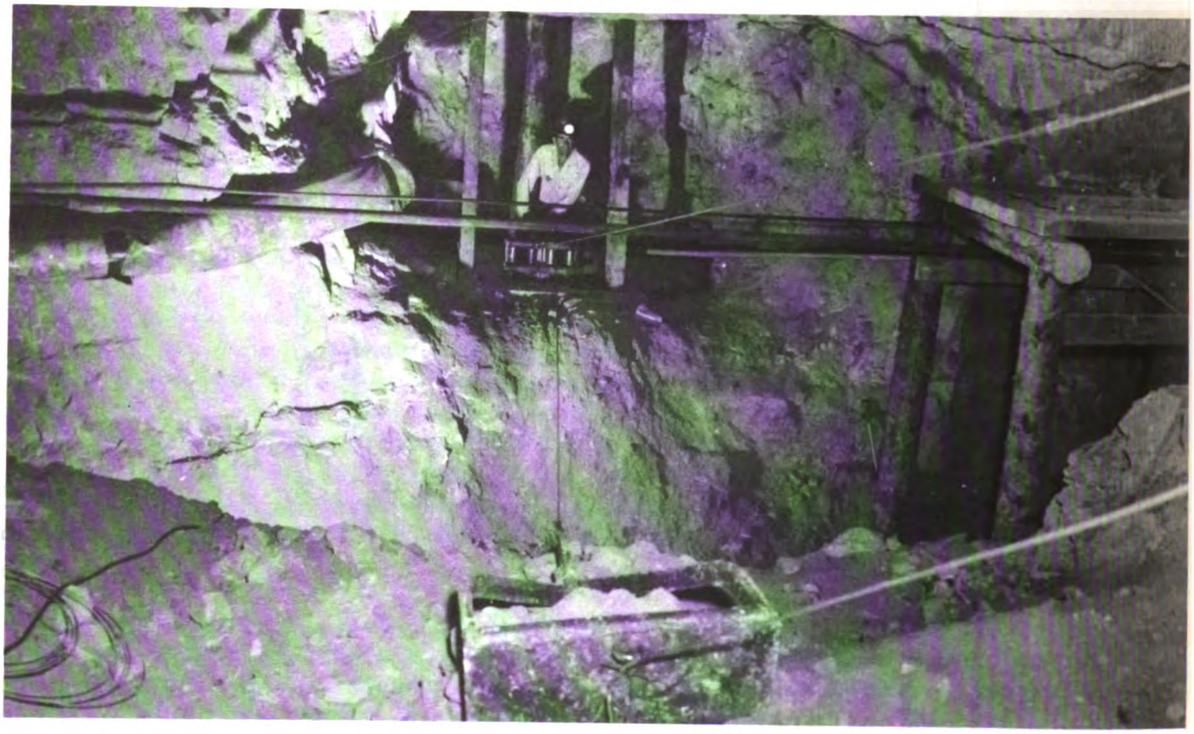


FIGURE 27. - Scraping Ore Into Drift, Dorothy Jean No. 1 Mine.

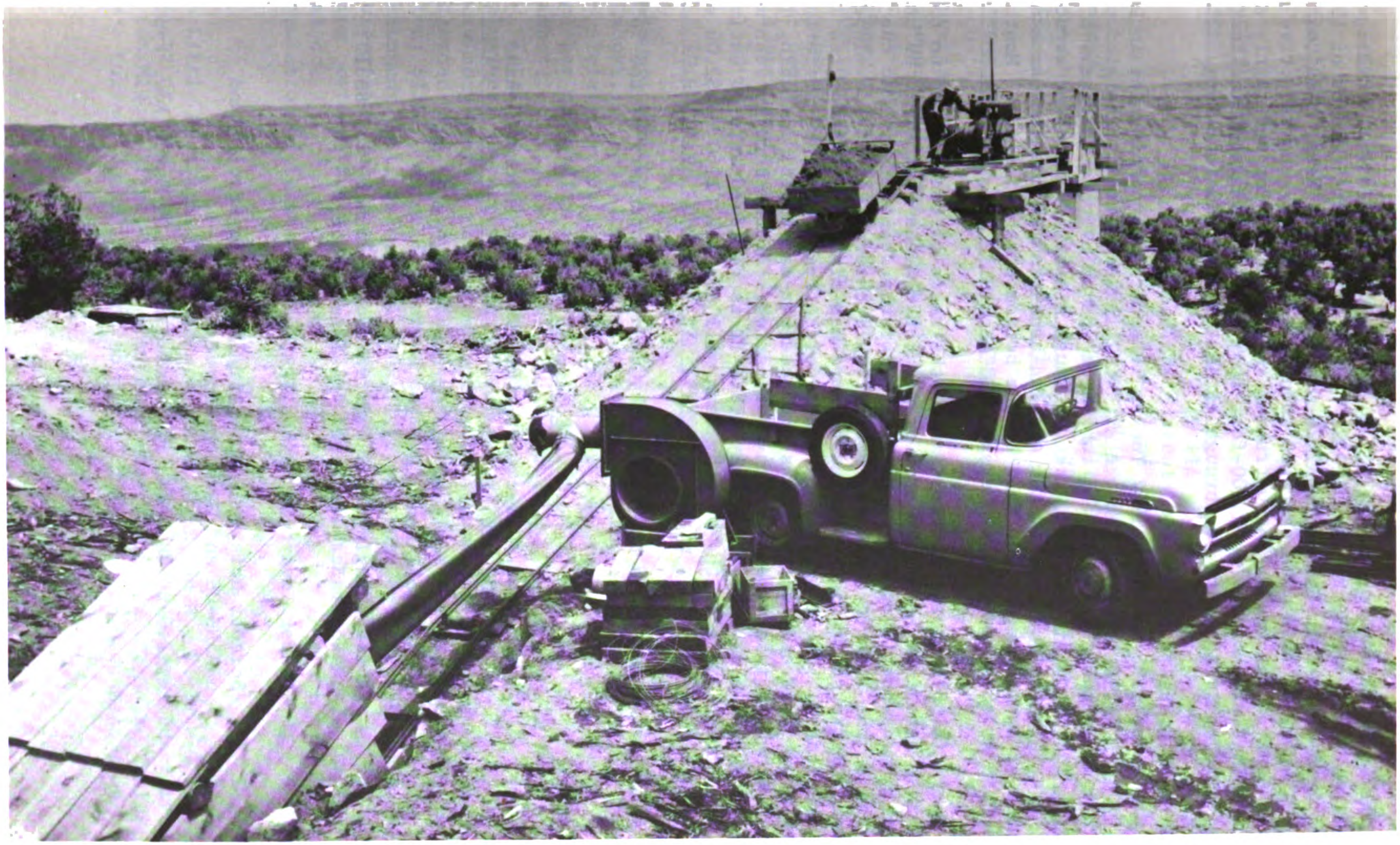


FIGURE 28. - Hoisting Ore to Dorothy Jean No. 1 Bin; Northeast Wall of Paradox Valley in Background.

The 14-month cost spread which follows represents Tucker's average mining costs from January 1956 to March 1957. During the first 5 months of 1956, Tucker leased the East Calamity No. 26 mine on Calamity Mesa, Mesa County, Colo. The ore at this mine averaged about 2 feet thick, and selective mining was necessary. The ore was hand-trammed through irregular and fairly extensive workings and hoisted up a 100-foot-long, 20°, underground incline; then it was hoisted to the surface through either of two, 200-foot-long, 20° inclines.

From June 1956 to March 1957 Tucker leased the Carpathia mine in Long Park. Tucker reported that the ore at this mine occurred in isolated pods that had a maximum thickness of 6 to 7 feet and an average thickness of about 4 feet. The Carpathia ore was worked through a minus 30° incline about 85 feet long. Tucker hand-mucked the ore and hand-trammed the cars an average distance of approximately 200 feet to the bottom of the incline. Monthly production at these two mines averaged 130 tons.

There is no accurate information as the ratio of tons of ore to tons of waste that were excavated from each of the three mines that might be used to estimate the probable direct costs at the Dorothy Jean relative to the costs incurred at the other two mines. However, all three mines are developed through similar short inclines, and the ore was mined and transported in about the same manner. The main factors that would affect costs are differences in ore thickness and continuity. Tons produced per man-shift, including Tucker's time, averaged 2.1 for the 14-month cost period. At the Dorothy Jean mine this average should be approximately 2.8. It is believed safe to estimate that the direct costs at the Dorothy Jean will average $1.50 to $2.00 a ton less than at the two other mines.

Mining equipment used at the Dorothy Jean mine consists of the following items:

Number	Equipment item
1	Compressor, 210-c.f.m., skid-mounted, Ingersoll-Rand IKA-210; diesel.
2	Drill, airleg-mounted, Gardner-Denver S48F and Ingersoll-Rand JL-4 leg.
1	Hoist, single-drum, Construction Machinery Co. SD310; 4-cylinder Wisconsin, gasoline motor.
1	Loader, overhead, Eimco 12B.
2	Scraper hoist, 2-drum, air, 5-hp., Ingersoll-Rand A5NN-OH and Gardner-Denver HEE.
3	Mine car, 18.5-cu.-ft., end-dump, C. S. Card, low, type Z.

Name of mines: East Calamity No. 26 and Carpathia.	Mining method: Open stoping with random pillar support.
Ore mined, tons: 1,814.	Period covered: January 1956 - March 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2]......	$1.99	$0.40	$0.33	$0.11	$0.32	$0.07	$0.30	$0.14	$3.66
Mining[3]...........	4.94	.99	.83	.27	.81	.19	.74	.33	9.10
Total........	6.93	1.39	1.16	.38	1.13	.26	1.04	.47	12.76

2. Indirect cost per ton of ore mined:

Depreciation[4]...	$1.27
Transportation, men and supplies.......................	.53
Social security...	.11
Workmen's compensation insurance.......................	.22
Other insurance and taxes..............................	.29
Accounting and other	.47
Camb board (employees).................................	.51
Bulldozer rental.......................................	.18
Total..	3.58

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor..	3.4
Total, including supervision.......................	3.8
Tons per man-shift:	
Labor..	2.3
Total, including supervision.......................	2.1
Explosives, 40-percent semigelatin, pounds per ton.....	4.2

1/ Supervisory cost is not a cash outlay by lessee but is based partly on an allotted $500 per month ($3.86 per ton) for lessee's labor and supervision; $2.47 per ton is charged to labor.

2/ Development unit costs, including $1.11 per ton for lessee's labor and supervision, are based on "dead-work" payments by lessor.

3/ Mining costs do not include cost of rail, pipe, timber, etc., furnished by lessor.

4/ Depreciation of lessee's equipment.

Little Dick Mine

The Little Dick mine is in secs. 19 and 30, T. 48 N., R. 17 W., Uravan mining district, Montrose County, Colo. The mine is on Dolores Bench overlooking the San Miguel River, about 4 miles northwest of Uravan, Colo. Dolores Bench is a curved, benchlike land form, which skirts Atkinson Mesa from

Atkinson Creek on the southeast to Mesa Creek on the northwest and lies about 200 feet below the rimrocks that cap the mesa. The bench is 700 to 1,000 feet above the Dolores and San Miguel Rivers. It is about 2,000 feet wide; its surface is gently undulating near the rim but becomes steeper with a cover of rock debris that has caved from the clifflike sides of the Cretaceous Burro Canyon formation and Dakota sandstone, which form much of the surface on Atkinson Mesa.

The beds near the Little Dick mine strike about N. 55° W. and dip about 2° NE. The ore bodies occur in broad sandstone lenses near the top of the Salt Wash. Most of the ore sandstone averages 60 to 65 feet thick,[26/] and is crossbedded and massive. The approximate ratio of U_3O_8 to V_2O_5 in the ore is 1 to 5.[27/]

The Little Dick mine is developed through an adit about 5,600 feet in altitude, which was driven into the rim about 35 feet below a narrow but relatively flat bench formed by an upper Salt Wash sandstone lense. (See fig. 29.)

The Little Dick claim was located in January 1910 by Clark Akers. Standard Chemical Co. acquired the claim in November 1912 and began producing ore from it in 1913. Standard Chemical operated a number of mines along the ore rim from its Dolores Camp, a short distance from the Little Dick mine. In the early days the ore was packed on burros down a steep trail to the road which is now Colorado State Highway 141.

Delbert Burbridge of Nucla, Colo., leased the Little Dick, Last Chance, Last Chance No. 1, and the south half of the Cistern claims and began work on them in February 1957. He, too, is one of the more experienced uranium-vanadium miners, having previously worked the Teapot Dome mine in Bull Canyon and the Squaw Park No. 1 mine in Utah. The Little Dick mine is typical of many early rim-developed mines on the Colorado Plateau. Burbridge uses equipment, such as slushers and airleg-mounted drills, that has become standard in Salt Wash mines. Unlike many operators, however, Burbridge prefers mule haulage underground.

During the short time Burbridge has worked the Little Dick mine, he has been engaged principally in mining a newly discovered extension of an ore body that a former lessee thought was worked out completely. Such discoveries are frequent on the Colorado Plateau. The ore was found about 600 feet north of the adit portal, and little "dead work" was required to reach the ore other than cleaning out back-filled stopes and setting a few stulls.

The thickness of the ore mined by Burbridge has ranged from 4 to 10 feet and has averaged about 5 feet. Thick ore and little development are the principal factors that enabled Burbridge to record the lower-than-average, 3-month costs shown in the tabulation.

[26/] McKay, E. J., Geology of the Red Canyon Quadrangle, Colorado: Geol. Survey Quadrangle Map GQ 58, 1955.

[27/] Jobin, D. A., Carnotite Resources of the Dolores Bench, Montrose County, Colorado: AEC, TEM 214, 1953.

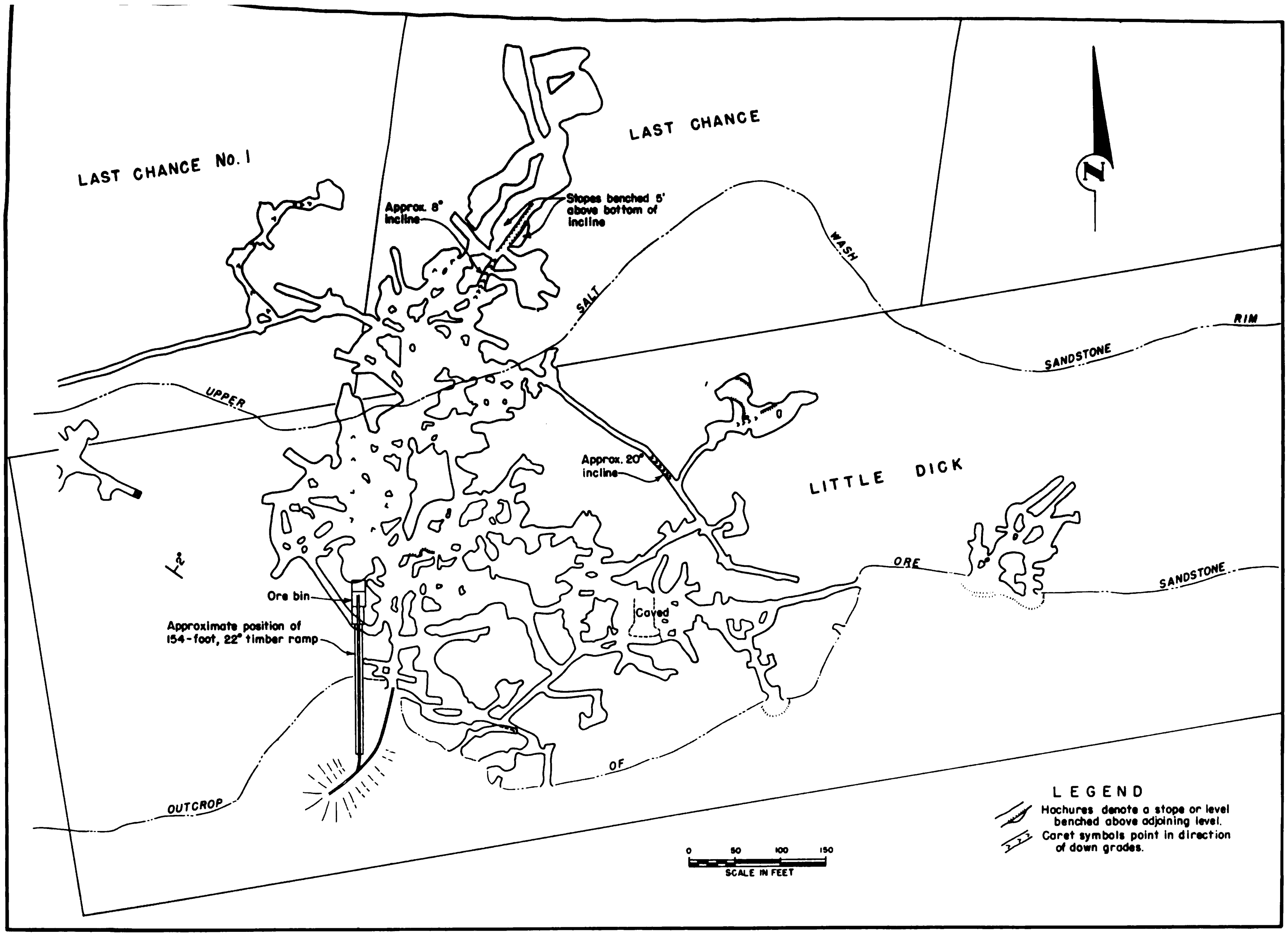

LAST CHANCE No. 1
LAST CHANCE
LITTLE DICK
N
Approx. 8° incline
Stopes benched 5' above bottom of incline
Approx. 20° incline
SALT
WASH
SANDSTONE
RIM
UPPER
ORE
SANDSTONE
OF
OUTCROP
Caved
Ore bin
Approximate position of 154-foot, 22° timber ramp
22°
LEGEND
Hochures denote a stope or level benched above adjoining level.
Caret symbols point in direction of down grades.
0
50
100
150
SCALE IN FEET

FIGURE 29. - Plan of Little Dick Mine.

Original from THE OHIO STATE UNIVERSITY

Blastholes are drilled with a Cleveland H10 drill mounted on a A1-92 telescoping airleg and an Ingersoll-Rand JR-38. Like other operators who use airleg-mounted drills, Burbridge reported that chuck replacement is a major part of drill maintenance. He stated that he must replace drill chucks about every 2 months, owing principally to misalining of the drill and steel. Burbridge uses 7/8-inch hexagonal drill steel and four-wing, 1-5/8-inch, one-use-type bits which he faces with acetylene tube-borium rod. He reported that he can increase the footage drilled with a one-use-type bit from 20 to approximately 150 feet by hard facing. He estimates that actual cash outlay for tube-borium rod and welding gas is about $0.25 per bit. In 1957 the bits cost $0.22 each in keg lots in the Uravan area. He breaks 5 feet of ore in a 6- by 7-foot heading, using 17 holes loaded with 40-percent semigelatin dynamite. The cut is a three-hole burn, and the holes are spaced in a nearly straight line. The 18.5-cubic-foot-capacity mine cars are loaded by 5-horsepower, double-drum scraper hoists and 30-inch scrapers at timber slides built over the track in the stopes. (See fig. 30.) From the stopes mined during the 3-month cost period, the mine cars were hoisted up a short incline by a small air-driven tugger hoist and hauled by a mule to the portal. (See fig. 31.) The length of the haul was 600 feet, and 10 minutes was required to make the round trip. Mine track is 12-pound rail laid to 18-inch gage.

Burbridge works his mule 2 shifts per day 6 days a week, but with rest intervals the mule actually works less than 8 hours per day. To keep the animal in good health, Burbridge feeds him grain five times a day and one-third bale of hay a day. The total monthly feed cost has ranged from $20.00 to $25.00, or about $0.035 per ton of ore hauled.

A small, single-drum, Construction Machinery Co. SD310 hoist is used to pull the ore cars from the portal up a 154-foot, 40°, timber-frame ramp to the top of a 28-ton ore bin built on the ledge above the portal. The hoist has an 8- by 14-inch drum and is rated as having a 2,600-pound pull at 150 f.p.m. Compressed air is furnished by a 210-c.f.m. Leroi compressor mounted on a percussion-drill rig and a smaller 105-c.f.m. Leroi compressore that is kept as a standby.

Burbridge is required by his lease agreement to produce 500 tons of ore a month. He has exceeded this amount by approximately 100 tons per month, but to produce this tonnage from the few working faces he has had to operate the mine two shifts a day 6 days a week. Labor on each shift consists of a driller, slusherman, trammer, and hoistman. The hourly wage is $2.00 for every man in the crew. Productivity was 2.9 tons per man-shift for the 3-month cost period. At this mine, as is necessary at any small mine for efficient operation, each man is capable of doing any job.

Equipment used at the Little Dick mine comprises the following items:

Number	Equipment item
1	Compressor, 2-stage, 210-c.f.m., Leroi, portable; diesel.
1	Compressor, 2-stage, 105-c.f.m., Leroi, portable; diesel.
1	Hoist, one 8- by 14-inch drum, 2,600-pound pull, 150 f.p.m., Construction Machinery Co. SD310; 4-cylinder Wisconsin gasoline motor.

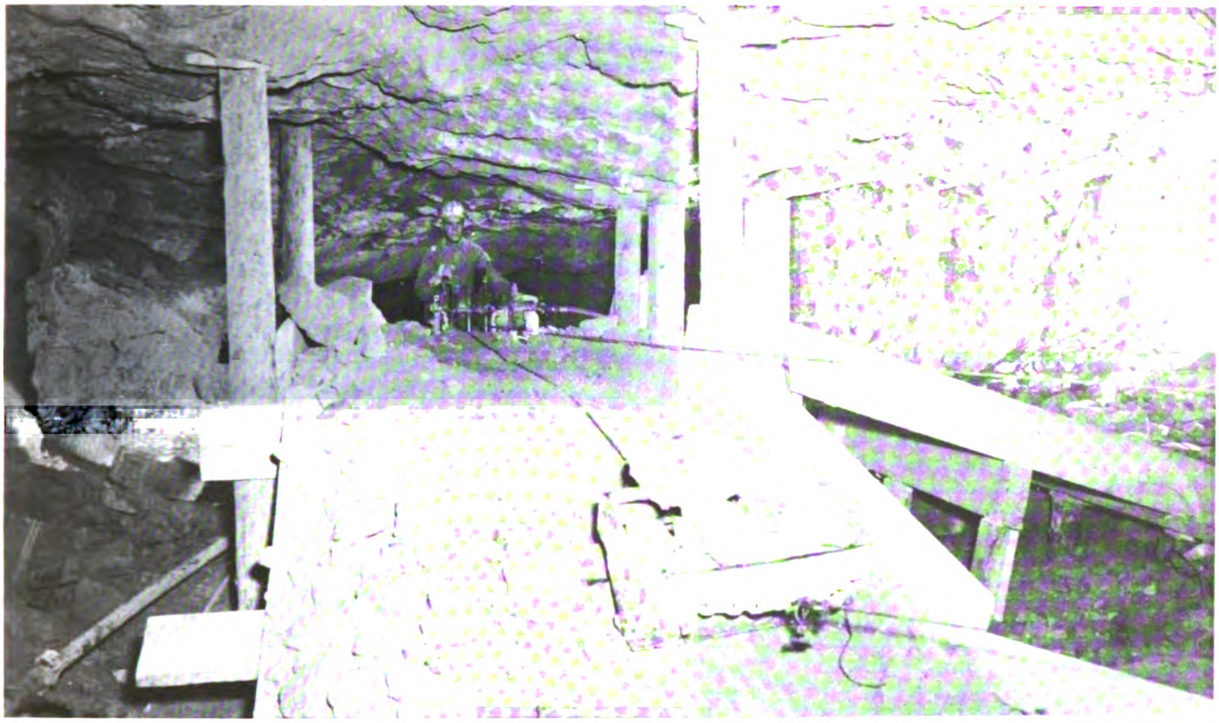


FIGURE 30. - Slushing Ore Into Mine Car Beneath Ramp, Little Dick Mine.

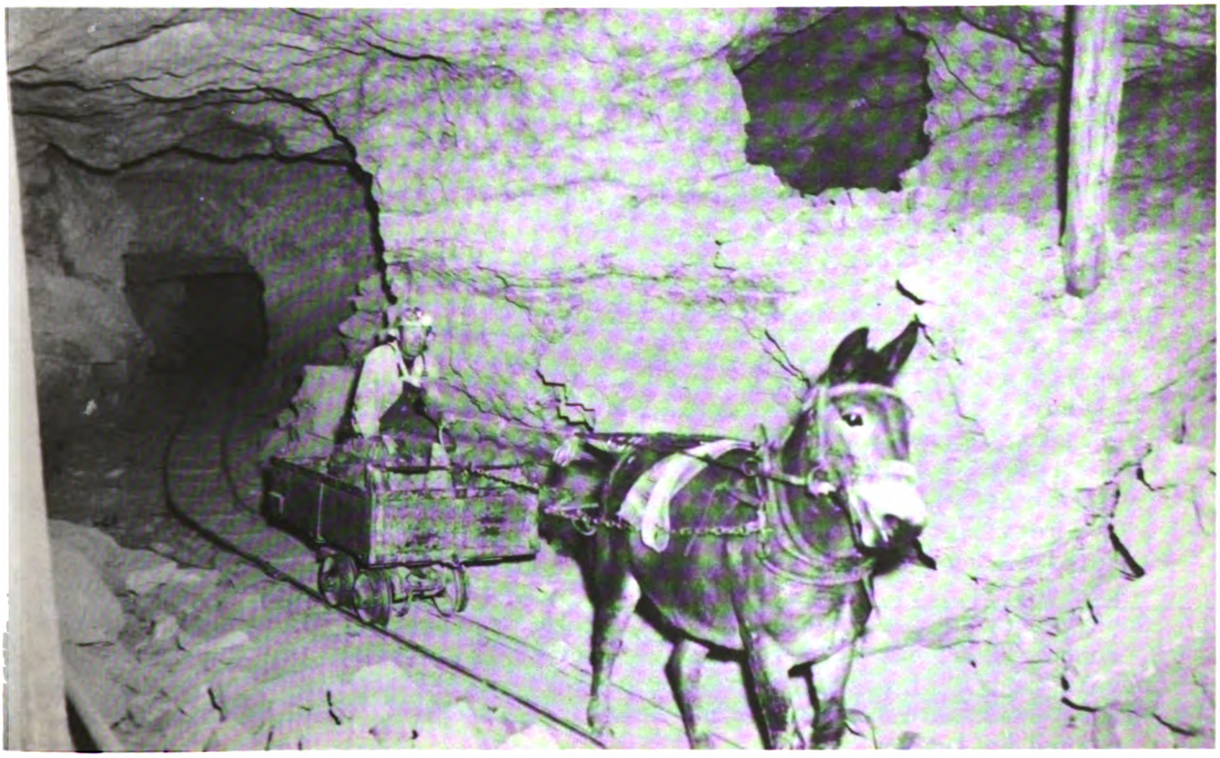


FIGURE 31. - Mule Haulage, Little Dick Mine.

Number	Equipment item
2	Drill, airleg-mounted, Cleveland H10 with A1-92 leg and Ingersoll-Rand JR-38.
2	Scraper hoist, 2-drum, air, 5-hp., Joy S-211.
4	Tugger hoist, 1-drum, air, 5-hp., Joy E-111 and Ingersoll-Rand
4	Mine car, 18.5-cu. ft., C. S. Card, low, type Z.
1	Mule.

Name of mine: Little Dick.
Mining method: Open stoping with random pillar support.
Ore mined, tons: 1,800.
Period covered: February - May 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2]	$0.25	-	-	-	-	-	-	-	$0.25
Mining[3]	4.61	$0.83	$0.58	$0.14	$0.34	$0.34	$0.45	$0.21	7.50
Total	4.86	.83	.58	.14	.34	.34	.45	.21	7.75

2. Indirect cost per ton of ore mined:

Depreciation[4]	$0.49
Transportation, men and supplies	.10
Social security	.11
Workmen's compensation insurance	.24
Unemployment insurance	.15
Other insurance and taxes	.02
Other	.02
Total	1.13

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor	2.4
Total, including supervision	2.8
Tons per man shift:	
Labor	3.3
Total, including supervision	2.9
Explosives, 40-percent semigelatin dynamite, pounds per ton	2.2

---

[1] Supervisory cost is not a cash outlay by lessee but an allotted $500 per month ($0.83 per ton) for lessee's supervision.

[2] Development unit costs are based on "dead-work" payments by lessor.

[3] Mining costs do not include the cost of rail, pipe, timber, etc., furnished by lessor.

[4] Depreciation of lessee's equipment.

Lumsden No. 2 Mine

The Lumsden No. 2 mine is on Beaver Mesa in sec. 36, T. 51 N., R. 20 W., Gateway mining district, Mesa County, Colo., about three-fourths mile east of the Colorado-Utah State line. The Lumsden Nos. 2 and 6 claims are on the south wall and near the head of Lumsden Canyon (fig. 32), about 5 miles southwest of Gateway, Colo. Access from Gateway is by a partly graveled uranium-ore haulage road that runs southward up John Brown Canyon, climbing sharply by means of switchbacks to the top of the mesa. The road is maintained by Mesa County, but during spring thaws, sections of the road become quagmires owing to the truck traffic. In long periods of dry, hot weather, the surface is pounded into a heavy mantle of dust.

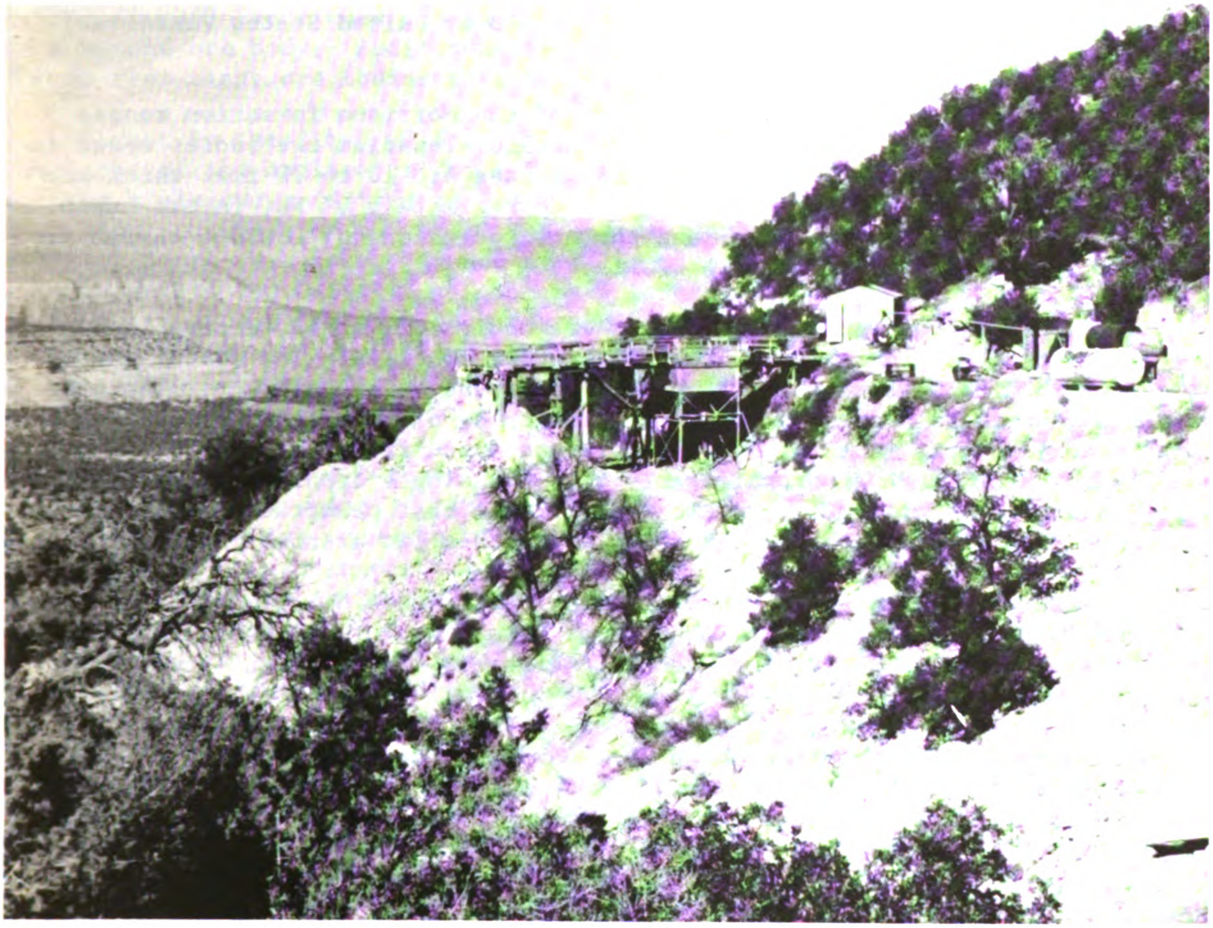


FIGURE 32. - Looking Northeast Down Lumsden Canyon From Lumsden No. 2 Adit.

The area is typical mesa land featured by prominent rims that drop off to terraces, all dissected by steep-walled canyons. The altitude is approximately 6,840 feet at the adit portal but ranges from 5,000 to 7,700 feet within a 2-mile radius. Yearly precipitation averages about 13 inches. Winter snows may accumulate to a depth of 3 feet, but snowfalls average about 6 inches. Violent storms of short duration may occur in any season. A few springs flow all year and furnish water for mine and camp use.

The early history of mining in the Gateway district is vague. Mining on Beaver Mesa reportedly began about 1913. Organized mining in Lumsden Canyon was begun by George Kuncle, of Grand Junction, about 1916 or 1917 and is believed to have been near the original group of Lumsden claims. No roads entered the district at the time, and the high-grade ore was transported by pack animals over a trail that led down Lumsden Canyon to Gateway. From Gateway the ore was freighted in wagons to the rail point at Whitewater, Colo. The lower grade ore was stockpiled and later hauled to mills when roads were constructed to the top of the mesa. The John Brown Canyon road was built in 1943 by the U.S. Grazing Service and has been improved steadily during the last 7 years. The Lumsden No. 2 claim was located in January 1939 by U & V Alloys Co. and the Lumdsen No. 6 claim in November 1943 by United States Vanadium Corp.

The thickness of the Salt Wash member of the Morrison formation ranges from 260 to 300 feet in the area, and the uranium-vanadium ore bodies occur in its upper sandstone lenses. The sandstone lenses are 10 to 70 feet thick and average about 40 feet thick. The beds dip approximately 3° NE. in the immediate vicinity of the Lumsden mine, and the ore bodies on the Lumsden claims are found at depths ranging from 35 to 220 feet.

The deposits consist of clusters of ore bodies of various sizes, generally connected by thin seams of uranium-vanadium minerals. The distribution of the ore bodies appears random, no definite trend being apparent. The unoxidized ore minerals are commonly referred to as black ores. The uranium-vanadium oxide ratio is about 1 to 4 in ores produced from Beaver Mesa, but locally the ratio may vary considerably within a single deposit. Consequently, experienced miners will drive toward a drill hole that penetrated good vanadium ore, even if samples from the hole indicated a low uranium content.

The maximum thickness of ore mined from the Lumsden No. 2 mine before May 1957 was 14 feet; the average thickness was 4 to 5 feet. Ore as thin as 10 inches is mined selectively, and even thinner seams that frequently contain 0.45 to 0.50 percent U_3O_8 are mined. Although thin bands of uranium-vanadium minerals often connect the ore pods, the thicker ore usually is sharply bounded and terminates abruptly. Sandstone and occasionally a lens of blue mudstone overlie the ore, and almost always a blue mudstone seam underlies it. The ore sandstone contains some water, which usually collects at low places on the undulating mudstone. Old timers who have worked in the immediate area stress the wisdom of following the water, so as to keep the bottoms of the workings in the mudstone and not drive above the ore zone.

Ralph D. Hickman, of Grand Junction, Colo., produces uranium-vanadium ore under the terms of two separate lease agreements, one with Union Carbide Nuclear Co. and the other with New Idria Mining & Chemical Co. His experience in uranium-vanadium mining began in 1943, when he leased the Black Dinah and Cripple Creek mines in Long Park from United States Vanadium Corp. Union Carbide Nuclear Co. has leased the Lumsden Nos. 2 and 6 claims to Hickman since October 1953. In October 1956, when one of the ore bodies was found to extend into ground covered by the Johnnie Mae No. 2 claim (controlled by New Idria Mining & Chemical Co.), an agreement was negotiated among the three parties. Under a lease agreement with New Idria Mining & Chemical Co. Hickman is permitted to mine and ship ore from the Johnnie Mae Nos. 1, 2, 4, 5, and 6 claims and receives 50 percent of the gross value of the ore; New Idria Mining & Chemical Co. is permitted to use the Lumsden No. 2 adit for mining purposes; and Union Carbide Nuclear Co. is guaranteed that ore from the Johnnie Mae claims will be shipped to its processing mills.

The Lumsden No. 2 mine is developed through a 6- by 7-foot adit, which was driven on a 1-percent grade from a point on the canyon wall to intersect the first ore at track level. (See fig. 33.) The adit was first driven S. 35° E. for 310 feet, then it was turned S. 12° W. and driven another 340 feet to a second ore body. Additional 6- by 7-foot development drifts are being driven from these ore bodies to intersect ore found by other drilling.

Except in the first 40 feet of the adit, no timber is required to support the backs of the haulage drifts. The ore bodies are relatively flat lying, and the haulageways (driven on 0.5- to 1.5-percent grades) for the most part pass along the base of the ore. The ore dips below track level at only two places. Short test holes, fanned at all angles from the workings with leg-mounted drills and 6-foot steel, became a favored and much used means of searching for ore extensions after one test hole found an ore body lying below the level of the track. To explore ground farther from the workings, Hickman drills 60-foot holes with a 3-inch drifter, using 1-inch, hexagonal, sectional steel with 1-7/8-inch insert-type bits.

Drills mounted on 4-foot airlegs are used when drifting, and drills on 3-foot legs when stoping. Hickman uses 7/8-inch, hexagonal drill steel with either the four-wing, one-use, Ingersoll-Rand Sandbit or the four-wing, 1-3/4-inch, one-use, tungsten carbide insert Liddicoat Tee Cee bit. The one-use Sandbit costs $0.54 in Uravan, and Hickman reported that it has the faster drilling rate of the two in his ground. It lasts for about 30 feet of drilling. The one-use Liddicoat Tee Cee bits costs $4.80 in Uravan, and Hickman estimates that this bit will drill about 400 feet before destruction.

Twenty holes are drilled to break 5 feet of ground in a 6- by 7-foot drift. As in most Salt Wash mines, a four-hole burn cut is used. The average drilling time for a drift round is about 2 hours. Forty-percent, ammonia, low-density dynamite is used. Hickman is one of the few operators mining Salt Wash ore who uses an ammonia-type dynamite. He reports that he gets the good fragmentation necessary for efficient hand mucking and that the slower explosion produces less fly material and piles the ore better.

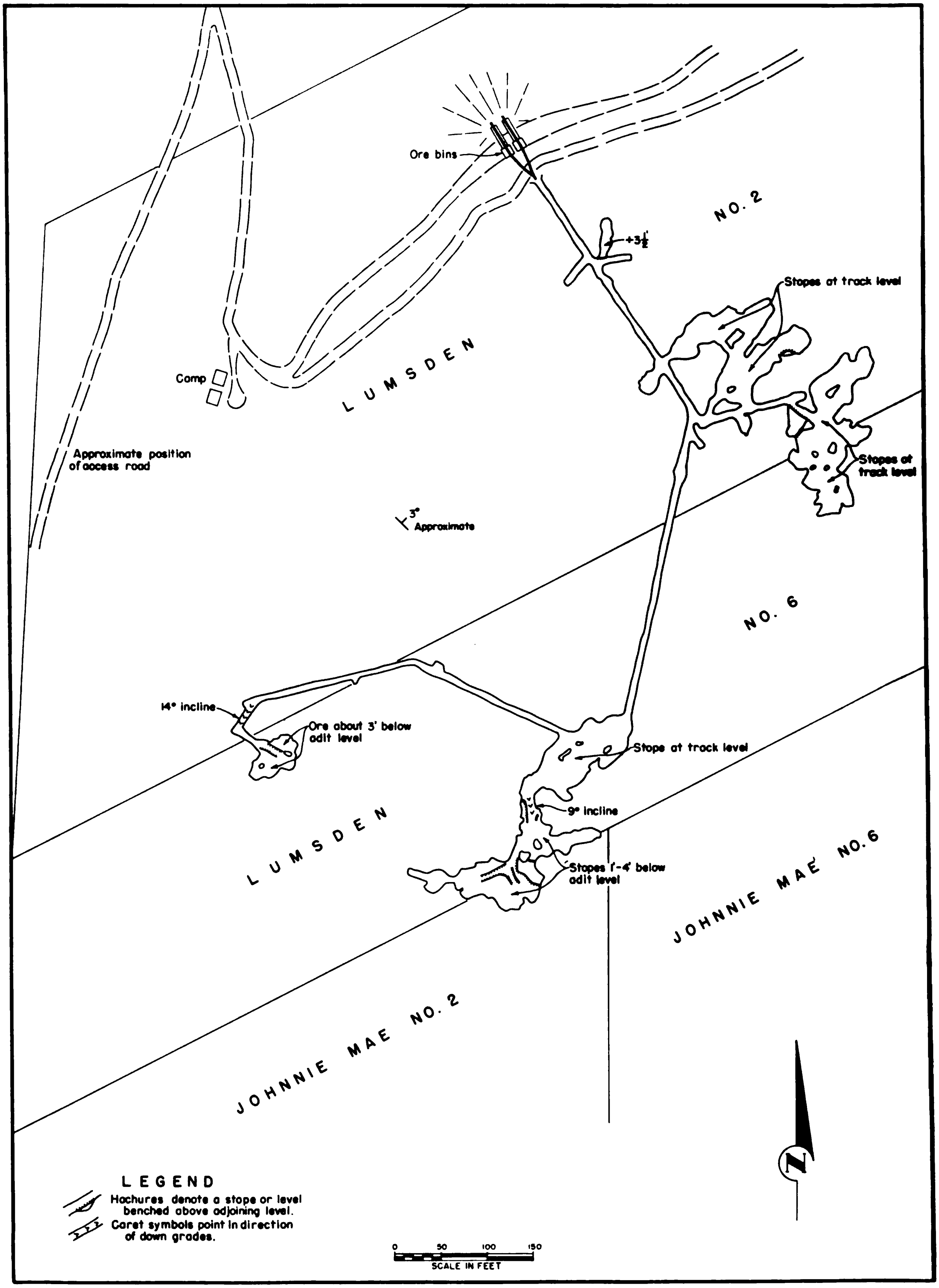

Ore bins
+3½'
NO. 2
Stopes at track level
Camp
LUMSDEN
Stopes at track level
Approximate position of access road
3° Approximate
NO. 6
14° incline
Ore about 3' below adit level
Stope at track level
9° incline
LUMSDEN
Stopes 1'-4' below adit level
JOHNNIE MAE NO. 6
JOHNNIE MAE NO. 2
N
LEGEND
Hachures denote a stope or level benched above adjoining level.
Caret symbols point in direction of down grades.
0
50
100
150
SCALE IN FEET

FIGURE 33. - Plan of Lumsden Mine.

Overhead loaders are used in drifts and hand loading in stopes. Hickman reports that, although he is aware that slushing would be a faster method of loading stope ore, he prefers to load by hand, as less dust is created and the miners have a better opportunity to separate ore from waste. All stope ore is shot onto steel mucking plats. In selective mining of a face, in which either the upper or lower part is ore and the other waste, the bottom section is always broken out first. After the lower part has been mucked out, the plats are shoved under the brow, and it is slabbed down. With a thin but promising ore lead that is high in the face, the miners follow the lead a few rounds to see if it will widen before they take up the bottom. As stipulated in the standard Union Carbide Nuclear Co. lease, no back filling is permitted.

On the average, Hickman keeps two of his three drillers in development headings to keep development work in balance with mining. If enough ore is in sight, one driller usually can break enough ore to maintain production. It is sometimes difficult to distinguish between development work and mining, as a development heading is often driven to follow a thin layer of ore that may widen enough every few rounds to merit saving, or the ore body may be no wider than the drift itself.

Ore and waste were being hand-trammed 1,200 feet to the surface in May 1957. Hickman believes that 1,200 feet is about the maximum distance cars can be hand-trammed economically. As work progresses still farther from the rim, it will be necessary to install a small air-driven locomotive. Hickman prefers the low 18.5-cubic-foot mine cars that were designed by C. S. Card Iron Works Co. to meet operating conditions on the plateau. By using 1-foot sideboards, Hickman increased the heaped capacity of cars of this type to about 2 tons. The four muckers work in pairs, loading and tramming the mine cars to the portal over 12-pound rail laid to 18-inch gage. Electric lighting is used extensively in the haulageways and stopes, and the miners can lay aside their regular cap lamps at their working places. The well-insulated, 110-volt electric lines that extend into the stopes can be taken down easily before blasting. Hickman is confident that electric lighting contributes to the well-being and efficiency of his miners.

Equipment used at the Lumsden No. 2 mine comprises the following items:

Number	Equipment item
1	Compressor, 550-c.f.m., 2-stage, stationary, Gardner-Denver WBJ; 4-cylinder Murphy diesel.
1	Compressor, 210-c.f.m., 2-stage, stationary, Gardner-Denver; Caterpillar D318 diesel. Standby unit.
2	Loader, overhead, Eimco 12B.
7	Drill, airleg-mounted, 5 Cleveland H10AL, 2 Ingersoll-Rand JR-38.
1	Drifter, Ingersoll-Rand DA-30.
1	Scraper hoist, 2-drum, air, 5-hp., Joy S-211.
2	Utility hoist, 1-drum, air, 7-1/2-hp., Ingersoll-Rand HU.
5	Mine car, 18.5-cu.-ft., end-dump, C. S. Card, low, type Z.

At the surface ore from the Lumsden claims is dumped into a 40-ton cribbed bin and from the Johnnie Mae claims into a 30-ton steel bin, both built over the haulage road.

In addition to his brother, Hickman employs three drillers who are paid $2.50 an hour and four muckers who are paid $2.00 per hour. The mine is operated 5 days a week.

Hickman has had an excellent safety record. He was presented the 1956 safety plaque for small mine operators in Colorado, awarded jointly by the Colorado Mining Association and the Colorado State Workmen's Compensation Insurance Fund.

Name of Mine: Lumsden No. 2.	Mining method: Open stoping with random pillar support.
Ore mined, tons: 5,258.	Period covered: January 1956 - April 1957.

1. Direct cost per ton of ore mined:

	Labor	Supervision[1]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2]......	$0.85	$0.15	$0.08	$0.02	$0.04	$0.02	$0.10	$0.02	$1.28
Mining[3]...........	7.00	1.28	.63	.16	.32	.19	.81	.21	10.60
Total.........	7.85	1.43	.71	.18	.36	.21	.91	.23	11.88

2. Indirect cost per ton of ore mined:

Depreciation[4]..	$0.37
Transportation, men and supplies......................	.06
Social security..	.15
Workmen's compensation insurance......................	.27
Unemployment compensation.............................	.18
Other insurance and taxes.............................	.04
Other..	.02
Total..................................	1.09

3. Costs in units of labor and explosives:

Man-hours per ton:	
Labor..	3.5
Total, including supervision......................	4.0
Tons per man-shift:	
Labor..	2.3
Total, including supervision......................	2.0
Explosives, 40-percent ammonia, dynamite, pounds per ton	2.7

---

[1] Supervisory cost is not a cash outlay by lessee but an allotted $500 per month ($1.43 per ton) for lessee's supervision.

[2] Development unit costs, including the supervisory cost of $0.15 per ton, are based on "dead-work" payments of lessor.

[3] Mining costs do not include the cost of rail, pipe, timber, etc., furnished by lessor.

[4] Depreciation of lessee's equipment.

Thunder Cloud No. 1 Mine

The unpatented Thunder Cloud No. 1 and Sunspot No. 2 claims are on Beaver Mesa in unsurveyed sec. 32, T. 51 N., R. 19 W., Gateway mining district, about 2 miles east of the Lumsden mine. The Thunder Cloud No. 1 mine is at an altitude of about 6,800 feet and is on the north side of Kaywood Point, a spur that extends toward the Dolores River to the east and separates John Brown and Lumsden Canyons. The Thunder Cloud No. 1 claim was located in July 1940 by U & V Alloys Co. and the Sunspot No. 2 claim in June 1952 by United States Vanadium Co. E. E. Horn, of Rifle, Colo., began developing the claims in November 1956. Before that time, Horn leased the Elva M No. 2 mine on Polar Mesa to the west.

The following is a brief description of the Thunder Cloud No. 1 operation. The unit mining costs are the combined average costs attained by Horn at both mines in 1956.

The Thunder Cloud No. 1 mine is entered through a 6- by 7-foot adit, which is being driven south toward exploratory drill holes that penetrated ore on the Sunspot No. 2 claim. The only ore produced to date has come from a small stope about 350 feet from the portal. Like the ore in many Salt Wash mines, this ore was not indicated by surface drilling. The ore has occurred as a 1- to 3-foot band of low-grade brown sandstone bounded by two thin, black, high-grade seams. Mudstone lies 2 to 3 feet below the ore. The low-grade ore is difficult to distinguish from waste rock, and a geiger counter is useful in identifying it. Occasionally, pods of high-grade black ore are found where the thin black seams coalesce. The ore has averaged 1-1/2 feet in thickness to date, and selective mining is mandatory. Horn estimated that ore stoped at the Elva M No. 2 mine has also averaged about 1-1/2 feet thick. This old mine has extensive workings and is developed through a 180-foot incline driven on a minus 20° dip.

The Thunder Cloud No. 2 adit is being driven on a 1-percent grade from a point on the canyon wall to the principal ore bodies underlying the Sunspot No. 2 claim. The adit will be below the ore, which will be mined through raises. Except for two drift sets at the portal, no timbering is required in the adit.

Horn uses equipment and methods that have become conventional in most Salt Wash mines. He uses a leg-mounted drill and prefers a high-carbon, 7/8-inch, hexagonal drill steel, with one-use, tungsten carbide insert, socket-type bits. (See fig. 34.) Horn reports that he has had poor results with hard-surfaced, one-use-type bits on Beaver Mesa. The 6- by 7-foot heading rounds are broken with 18 holes loaded with 40-percent semigelatin dynamite; a four-hole burn cut is drilled high in the face. Stoping to date has been at track level; broken ore is loaded with an overhead loader into 18.5-cubic-foot-capacity mine cars and trammed to the 30-ton steel ore bin at the surface. Mine track is 12-pound rail laid to 18-inch gage. Horn has found the mortar hoe useful in cleaning up fines in thin ore bodies.

During the year for which costs were computed Horn employed one to three men. Mining thin ore selectively results in higher than average unit mining

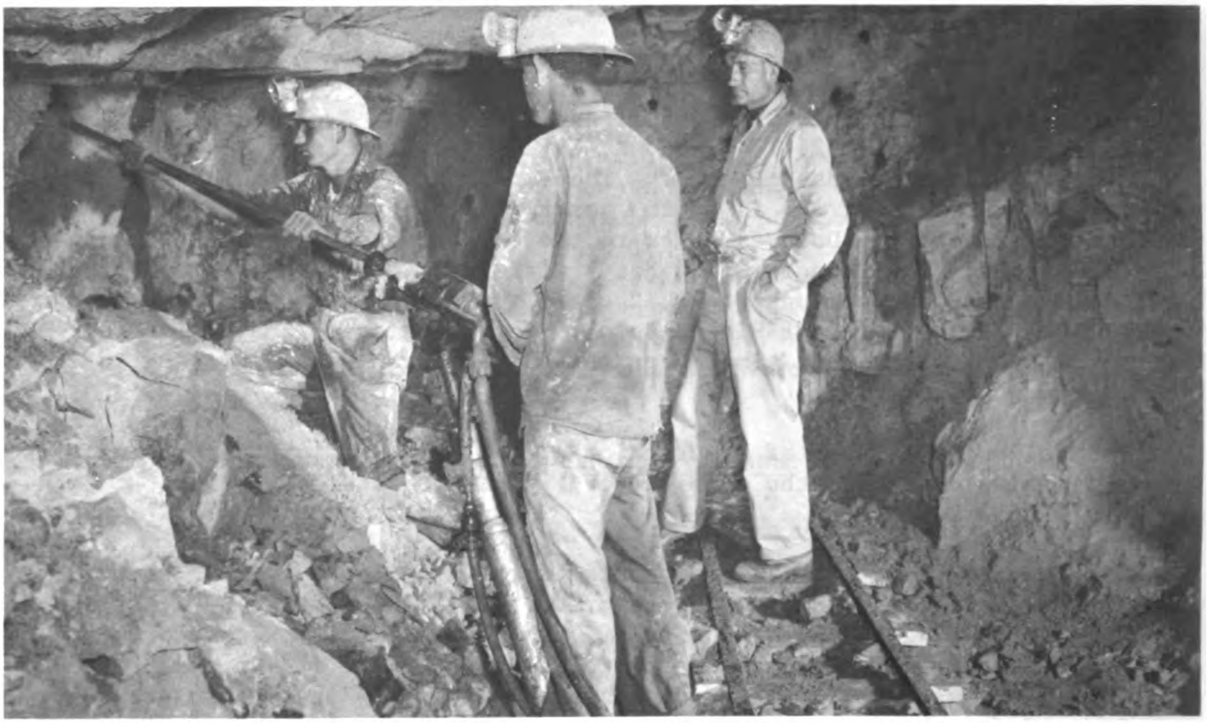


FIGURE 34. - Drilling Ore, Thunder Cloud No. 1 Mine.

costs, as shown on Horn's cost sheet. The large amount of development work required for producing each ton of ore is reflected in higher than average unit development costs, lower than average labor-performance figures, and high consumption of explosives. These figures are understandable when one considers the type of the ore bodies.

Equipment used at the Thunder Cloud mine comprises the following items:

Number	Equipment item
1	Compressor, 210-c.f.m., 2-stage, portable, Leroi.
1	Drill, airleg-mounted, Cleveland, H10AL.
1	Loader, overhead, Eimco 12B.
2	Mine car, 18.5-cu.-ft., C. S. Card, low, type Z.

Name of mines:	Thunder Cloud No. 1 and Elva M No. 2.	**Mining method**:	Open stoping with random pillar support.
Ore mined, tons:	805.	**Period covered**:	January 1956 - January 1957.

1. **Direct cost per ton of ore mined**:

	Labor	Supervision[1]	Explosives	Drill steel and bits	Fuel oil, gas, etc.	Repairs and maintenance	Equipment rental	Other supplies	Total
Development[2]......	$4.10	$0.82	$0.49	$0.34	$0.39	$0.04	$0.07	$0.18	$6.43
Mining[3]...........	9.16	1.83	1.10	.76	.87	.10	.16	.40	14.38
Total.........	13.26	2.65	1.59	1.10	1.26	.14	.23	.58	20.81

2. **Indirect cost per ton of ore mined**:

Depreciation[4].......................................	$1.97
Transportation, men and supplies..................	.17
Social security..................................	.16
Workmen's compensation insurance..................	.37
Other insurance and taxes.........................	.25
Accounting and other..............................	.08
Camp rent for employees...........................	.21
Total....................................	3.21

3. **Costs in units of labor and explosives**:

Man-hours per ton:	
Labor..	6.7
Total, including supervision.................	7.9
Tons per man-shift:	
Labor..	1.2
Total, including supervision.................	1.0
Explosives, 40-percent semigelatin, pounds per ton	5.6

1/ Supervisory cost is not a cash outlay by lessee but is based partly on an allotted $450 per month ($6.71 per ton) for lessee's labor and supervision; $4.06 per ton is charged to labor.

2/ Development unit costs, including $2.17 for lessee's labor and supervision, are based on "dead-work" payments by lessor.

3/ Mining costs do not include the cost of pipe, track, timber, etc., furnished by lessor.

4/ Depreciation of lessee's equipment.

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